Interactive Computing to Augment the Human Interpretation of the 12-lead Electrocardiogram

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(I can confirm that the word count of this Thesis is less than 100,000 words)

Table of Contents

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This thesis is dedicated to my parents, Edmund and Elizabeth

Abstract

Introduction: *The 12-lead Electrocardiogram (ECG) has been used to detect cardiac abnormalities in the same format for more than 70 years. However, due to the complex nature of 12-lead ECG interpretation, there is a significant cognitive workload required from the interpreter. This complexity in ECG interpretation often leads to errors in diagnosis and subsequent treatment.*

Objectives: *To improve interpretation accuracy and reduce missed co-abnormalities.*
Methods: *1) An interactive computing system was developed to guide the decision-making process of a clinician when interpreting the ECG. The system decomposes the interpretation process into a recognised series of sub-tasks and encourages the clinician to systematically interpret the ECG, coined 'Interactive Progressive based Interpretation' (IPI). 2) A Differential Diagnoses Algorithm (DDA) was developed to compare human ECG annotations, collected using the IPI system, against recognised diagnostic criteria. This enabled diagnostic suggestions to be generated using a novel man-machine model. The subsequent system was created using web technologies. The hypothesis was tested using a one-arm (IPI) and counterbalanced studies (IPI+DDA).*

Results: *A total of 558 interpretations were collected from 80 participants. The IPI model increased accuracy by 13.4%, whilst the IPI+DDA approach was also shown to improve diagnostic accuracy (8.7%). In both studies, interpreter self-rated confidence increased but interpretation duration increased six fold. The IPI+DDA suggested the correct interpretation more often than the human interpreter in 7/10 cases. Human interpretation accuracy increased to 70% when seven suggestions were generated.*

Conclusion: *The IPI and IPI+DDA models improve diagnostic accuracy, at the expense of time. It was found; 1) the decision support tool increased the number of correct interpretations, 2) the DDA algorithm suggested the correct interpretation more often than humans, and 3) as many as 7 computerized diagnostic suggestions augmented human decision making in ECG interpretation.*

[292 words]

Abbreviations

All abbreviation used within this PhD thesis have identified and listed below;

ACC	American College of Cardiology
AHA	American Heart Association
AHRQ	Agency for Health care Research and Quality
AI	Artificial Intelligence
AJAX	Asynchronous JavaScript And XML
AMI	Acute Myocardial Infarction
ASL	Applied Science Laboratories
AV	Atrioventricular
BCS	British Cardiovascular Society
BSPM	Body Surface Potential Map
CDSS	Clinical Decision Support Systems
COCATS	Core Cardiology Training Symposium
CUI	Common User Interface
CVD	Cardiovascular Disease
DDA	Differential Diagnoses Algorithm
DDS	Decision Support Systems
DFD	Data Flow Diagram
DICOM	Digital Imaging and Communications in Medicine
ECG	Electrocardiogram
EEG	Electroencephalogram
EHR	Electronic Patient Health Record
EMR	Electronic Medical Records
ESC	European Society of Cardiology
FDA	US Food and Drug Administration
GCT	Goldberger’s Central Terminal
HCI	Human Computer Interface
HIMSS	Health Information and Management Systems Society
HL7	Health Level Seven
HR	Heart Rate
HTML	HyperText Markup Language

ICE	Institute of Clinical Evaluation
IPI	Interactive Progressive-based Interpretation
JS	JavaScript
JSON	JavaScript Object NotatioN
LA	Left Arm
LCD	Liquid Crystal Display
LL	Left Leg
LVH	Left Ventricular Hypertrophy
MI	Myocardial Infarction
MRI	Magnetic Resonance Imaging
ms	Milliseconds
mV	Millivolts
NHS	National Health Service
NIST	National Institute for Standards and Technology
PC	Personal Computer
PDF	Portable Document Format
PHP	Hypertext Pre-processor
PNG	Portable Network Graphics
QTc	Corrected QT interval
R	*Programming language*
RA	Right Arm
RIA	Rich Internet Application
RL	Right Leg
SA	Sinoatrial
SPR	Specialist registrar
STEMI	ST Elevation Myocardial Infarction
UK	United Kingdom
URL	Uniform Resource Locator
USA	United States of America
WCT	Wilson Central Terminal
WHO	World Health Organisation
XML	eXtensible Markup Language

Note on Access to Contents

Chapter 1:
Introduction, rationale and contributions to knowledge

1.1 Introduction

The World Health Organisation (WHO) identifies Cardiovascular Disease (CVD) as the leading cause of morbidity, accounting for 30% of annual deaths worldwide [1]. As the human heart is a vital organ used to transport oxygen and minerals to tissues throughout the body, it is imperative to optimise the early detection of CVD [2]. With CVD being an umbrella term used to describe a number of cardiac abnormalities, a number of decision support systems have been developed to assess the cardiac state of a patient.

A most prevalent diagnostic tool used in the detection of CVD is the 12-lead Electrocardiogram (ECG), which can be found ubiquitously in hospitals and health centres throughout the world. The 12-lead ECG presents the electrical activity of the heart as a series of waveforms for a clinician to interpret. This diagnostic tool is used extensively as cardiac abnormalities often manifest in its waveforms, as well as being rapid and inexpensive to conduct [3]. Therefore, this interpretation of waveforms has become a fundamental part in the assessment of cardiac abnormalities.

Although the 12-lead ECG has become a key component in the detection of CVD, it is often difficult to interpret due to it requiring an extensive knowledge-base in cardiac pathology and diagnostic criteria [4] as well as its complex presentation which has remained unchanged for more than 70 years [5]. This can force a significant cognitive workload upon an interpreter. Hence, ECG interpretation proficiency is often found to be substandard with up to 33% of ECG interpretations per annum containing an error of significant importance [6]. Nonetheless, definitions of competency in ECG interpretation are diverse [6], [7], and even among experts there is often a degree of variability in interpretations of the same ECG [6], [8]. It has also been identified the current presentation of cardiac waveforms promote hasty reactions in the cardiac assessment of a patient [8], [9].

To counter these concerns, computerised decision support algorithms have been developed to enhance the 12-lead ECG. However, although computerised decision support algorithms have progressed significantly and have become exceedingly sophisticated since their inception in the early 1970s, they offer their own drawbacks. Namely, computerised diagnoses can be inaccurate [10]–[15], it is often difficult to accommodate the complexity of information required to make an informed decision [16], [17], incorrect computerised diagnoses have a detrimental effect on the interpretation performance of an interpreter [11], [18], [19], a lack of accountability [20], and a number of cognitive biases are often present within an interpreter [18], [21]. Therefore, almost exclusively, it is recommended that the human interpreter should be involved in the decision making process [6], [22]–[26].

As the digitisation of health services is becoming increasingly prevalent [27], it is vital to integrate the ECG in the upcoming healthcare digitisation process [27]. This opportunity to incorporate modern technologies within the interpretation process leads to the need for further research to better understand the difficulties within ECG interpretation and thereafter incorporate advantageous digital decision support tools.

1.2 Rationale and research aim

Given the degree of prevalence in which the 12-lead ECG is used in the detection of CVD, it is apparent that the 12-lead ECG should be digitally augmented to better assist a clinician in their diagnostic decision making. Therefore, the aim of the research is to create novel, interactive, computerised methods to provide clinical decision support to augment the human interpretation of the 12-lead electrocardiogram. With this in mind, the research question addressed within this thesis is as follows "How can 12-lead Electrocardiogram interpretation be digitally augmented to improve interpretation accuracy?"

1.3 Research objectives

To realise the aim of this research a number of research objectives have been identified and listed below;

Objective 1: To deconstruct the complicated task of interpreting a 12-lead ECG into more manageable sub-tasks

Objective 2: To develop interactive software which facilitates new method(s) of ECG interpretation

Objective 3: To provide a ubiquitous interactive decision support platform that can be integrated with current interpretation procedures

Objective 4: To provide a decision support algorithm that suggests diagnoses resulting from interpreter ECG annotations

Objective 5: To improve diagnostic accuracy in ECG interpretation with the use of this interactive decision support platform

Objective 6: To assess level of interpretation competency within interpretation with the 12-lead ECG

Objective 7: To reduce the level of annotation/interpretation variability with the 12-lead ECG

1.4 Thesis overview

This section provides an overview of the following seven Chapters within this Thesis. Beginning with Chapter 2, a literature review has been presented. Chapters 3 and 4, discuss the development of a system which presents a segmented 12-lead ECG. Chapters 5 and 6 then augment the model presented in Chapters 3 and 4 with a differential diagnoses algorithm. Chapter 7 presents research conducted with an industry partner, observations on interpreter annotation recording, diversification of Thesis concepts, limitations of research conducted and conclusive remarks. The final chapter includes Appendices and project source code.

Chapter 2: This chapter provides a review of the literature surrounding Thesis concepts. This chapter begins by providing the reader with foundational knowledge on the mechanics of electrocardiology, identifying the 12-lead Electrocardiogram as the primary method of diagnostic support in detecting CVD, and conveying its limitations. This chapter then progresses to highlight opportunities arising from digital technology to augment the interpretation of the 12-lead ECG using computer-based decision support and human-computer interaction.

Chapter 3: This chapter highlights specific limitations relating to 12-lead ECG interpretation and presents a model which aims to combat these concerns. This model facilitates the presentation of a segmented 12-lead ECG across a series of dynamic webpages.

Chapter 4: This chapter provides an evaluation of the model presented in Chapter 3. It discusses the study methodology and protocol, system infrastructure, analysis methods, and interprets the results.

Chapter 5: This chapter introduces a differential diagnoses algorithm. This differential diagnosis algorithm augments the 12-lead ECG interpretation model described in Chapter 3. To achieve this, the algorithm collects interpreter annotations and matches them against clinical diagnostic criteria, enabling the generation of 'suggested' diagnoses based on human annotations.

Chapter 6: This chapter describes the evaluation of the differential diagnoses algorithm discussed in Chapter 5. It discusses the study methodology and protocol, system infrastructure, analysis methods, and interprets the results. Including insights into suggestion presentation and a comparison between human interpretation accuracy and algorithm accuracy.

Chapter 7: This chapter presents research conducted with an industry partner (AMPS-LLC) to create a potential pathway to practice for models discussed within this Thesis. Chapter 7 also conveys observations on interpreter annotation recording (i.e. variability of annotations), diversification of Thesis concepts (how a sequential approach may benefit other medical domains (i.e. radiography)), limitations of research conducted and conclusive remarks.

Chapter 8: This chapter presents appendices alluded to throughout this Thesis. Finally, the source code for the discussed systems is presented.

1.5 Contributions to knowledge

Through reviewing the key points within this research, it was discovered a series of contributions have been made to the field of medical informatics. Contributions to knowledge have been itemised below;

1. Assessment of diagnostic accuracy in ECG interpretation using web technologies to structure the interpretation process
2. Development of a cognitive engineering system which;
    a. deconstructs a complicated task (ECG interpretation) into manageable exercises
    b. implements a checklist for the interpretation process
    c. manages cognitive load
    d. reduces interpretation errors
    e. improves diagnostic accuracy
    f. discovers the variability of ECG reporting
3. Development of an augmented decision support system which;
    a. generates suggested diagnoses resulting from an interpreter's ECG interpretation annotations
        i. by comparing annotations against recognised diagnostic criteria
    b. promotes differential diagnoses
    c. attenuates cognitive biases
    d. increases the number of correct interpretations
    e. increased interpreter self-confidence in interpretation
    f. algorithm produced more correct interpretations than the human interpreter
    g. identified that displaying up to seven potential diagnoses for an interpreter to consider can improve diagnostic accuracy

This thesis can be distilled into two primary contributions to knowledge. The first contribution is how human-computer interaction principals can be implemented to facilitate a cognitive engineering methodology in medical informatics, specifically 12-lead ECG interpretation. The second major contribution found within this thesis extends the previous contribution by illustrating how augmenting the human decision making process with a computerised decision support system could create an optimum man-machine model for ECG interpretation.

1.6 Published works

1.6.1 Journal articles

1. **Cairns, A. W**., Bond, R. R., Finlay, D. D., Breen, C., Guldenring, D., Gaffney, R., … Henn, P. (2016). A computer-human interaction model to improve the diagnostic accuracy and clinical decision-making during 12-lead electrocardiogram interpretation. *Journal of Biomedical Informatics*, *64*, 93–107.
2. **Cairns, A. W**., Bond, R. R., Finlay, D. D., Guldenring, D., Badilini, F., Libretti, G., … Leslie, S. J. (2017). A decision support system and rule-based algorithm to augment the human interpretation of the 12-lead electrocardiogram. *Journal of Electrocardiology*, 50, 781-786

1.6.2 Conference articles

1. **Cairns, A. W.**, Bond, R. R., Finlay, D. D., Breen, C. J., Guldenring, D., Gaffney, R., … Peace, A. J. (2015). Interactive progressive-based approach to aid the human interpretation of the 12-lead Electrocardiogram. In *Computing in Cardiology*, Nice, France, pp. 197–200. IEEE.
2. **Cairns, A. W.**, Bond, R. R., Finlay, D. D., & Guldenring, D. (2016). An annotation driven rule-based algorithm for suggesting multiple 12-lead ECG interpretations. *Computing in Cardiology*. Vancouver, BC, pp. 1-4. IEEE

3. **Cairns, A. W.**, Bond, R. R., Finlay, D. D., Guldenring, D., Badilini, F., Libretti, G., & Peace, A. J. (2017). Parsing HL7 aECG Files and Segmenting Leads for Interactive Progressive-based Interpretation of the 12-lead Electrocardiogram. *Computing in Cardiology*. Rennes, France (In publication) IEEE

1.6.3 Co-authored papers

1. Peace, A., Ramsewak, A., **Cairns, A.W.**, Finlay, D., Guldenring, D., Clifford, G., & Bond, R. (2015). Using computerised interactive response technology to assess electrocardiographers and for aggregating diagnoses. *Journal of Electrocardiology*, 48(6), pp. 995-999
2. Bond, R. R., Finlay, D. D., McLaughlin, J., Guldenring, D., **Cairns, A.W.**, Kennedy, A., … Peace, A. (2016). Human factors analysis of the CardioQuick Patch®: A novel engineering solution to the problem of electrode misplacement during 12-lead electrocardiogram acquisition. *Journal of Electrocardiology*, *49*(6), pp. 911-918
3. Sassi, R., Bond, R. R., **Cairns, A.W.**, Finlay, D. D., Guldenring, D., Libretti, G., … Badilini, F. (2017). PDF-ECG in clinical practice: A model for long-term preservation of digital 12-lead ECG data. *Journal of Electrocardiology*, 50(6), pp. 776-780
4. McLaughlin, L., Woznitza N., **Cairns, A.W**., McFadden, S., Bond, R., Hughes, C., Elsayed, A., Finlay, D., McConnell, J., A digital training platform for interpreting radiographic images of the chest. *Under review for publication*

1.6.4 Conference contributions (published abstracts)

1. **Cairns, A.W.**, Bond, Raymond, Finlay, Dewar, Breen, Cathal, J, Guldenring, Daniel, Gaffney, Robert, Henn, Pat and Peace, Aaron (2015) Interactive computersied approach to guide human interpretation of the 12-lead electrocardiogram. In: *7th Annual Translational Medicine Conference, Derry/Londonderry, Northern Ireland. CTRIC*.
2. **Cairns, A.W.**, Bond, Raymond, Breen, Cathal, Finlay, Dewar, Guldenring, Daniel and Peace, Aaron (2016) Variability of human-annotations of 12-lead ECG features collected using a web system: Students vs. practitioners. In: *International Society for Computerised Electrocardiology, St. Simons Island, GA, USA*
3. **Cairns, A.W.**, Bond, R. R., Finlay, D., Breen, C., Guldenring, D., Gaffney, R., … Peace, A. (2016). A novel human-computer interface creating a framework for the cognitive ergonomics of ECG interpretation. In *Irish Human Computer Interaction*, *Cork*, *Ireland*

1.6.5 Secondment

1. As part of the body of work undertaken throughout this Thesis a one month secondment was undertaken with an industry partner, AMPS-LLC. This created a platform for further research in this field.

Chapter 2:
Towards clinical decision support systems in 12-lead electrocardiography

2.1 Computerised Electrocardiology

2.1 Electrocardiography

According to the World Health Organisation (WHO) the primary cause of death worldwide is Cardiovascular disease (CVD). CVD is a container term used to consolidate numerous diseases affecting the cardiovascular system. Annual mortality for CVD is 17.1 million people, accounting for 30% of worldwide deaths every year. This substantial figure is expected to rise with projections determining 23.6 million people will die as a result of CVD in 2030.

To assist diagnosis of CVD numerous non-invasive diagnostic tools have been developed, including, Magnetic Resonance Imaging (MRI), echocardiography, Positron Emission Tomography (PET). One of the primary, and most common, methods of detecting CVD is electrocardiography. Despite this, in order for a clinician to maximise the potential of an Electrocardiogram (ECG), a clinician must comprehend and interpret a plethora of information relating to the cardiovascular system, the electrical conduction system of the heart, and wider medicine in general.

This chapter begins to allude to some of these complex concepts, as well as illustrating approaches taken to assist the interpreter in assessing the cardiac state of a patient via an ECG. This chapter also conveys human-computer interaction principles and recommendations for clinical decision support systems in ECG interpretation.

2.1.1 History of the electrocardiology

The existence of the human heart was first noted in ancient Greece and was named '*Kardia'*, modernised to 'cardiac'. By 200 AD it was known that the heart helped the blood to flow around the body. Harvey (1578-1667) distinguished that the circulation of blood throughout the body was due to a muscular pumping action produced by the myocardium (heart muscle) [28].

The human heart is a vital organ located in the mediastinal cavity at the intersection between the two lungs, the sternum and the spine. The heart is typically 12.5cm x 9cm x 6cm in dimension and weighs between 255g and 340g [29]–[31]. The heart and the cardiovascular system transports oxygen and minerals to tissues throughout the body as well as transporting metabolic waste like carbon dioxide and urea [2]. The heart itself contains four chambers. The two superior chambers are called the atria which serve as reservoirs for the inferior chambers, which are known as the ventricles [29].

2.1.1.1 Cardiac circulation

The right atrium receives deoxygenated blood via the superior vena cava [28]. This blood is released into the right ventricle through the atrioventricular tricuspid valve, which is a 'one-way door' that prevents backflow (regurgitation). The right ventricle forces the deoxygenated blood through the pulmonary semilunar valve. This deoxygenated blood travels to the lungs to deposit carbon dioxide and be enriched with oxygen. The oxygen-rich blood then journeys to the left atrium and completes the circuit known as *pulmonary circulation* [29].

Upon returning from the lungs oxygenated blood enters the left atrium [28]. The atrioventricular mitral valve releases the blood into the most muscular part of the heart, the left ventricle. When the left ventricle contracts, the oxygenated blood is forced through the semilunar aortic valve. The left ventricle needs to create enough pressure to ensure that the blood flows into the aorta and journeys to the remainder of the body. This completes the *systemic circulation*. [29] Contraction in both ventricles is known as 'systole' and when the ventricles relax this is known as 'diastole' [32]. The often-described '*lub' and 'dub'* sounds are known as S1 and S2 respectively. This is the noise generated by the closing of the atrioventricular and semilunar valves respectively [32], [33].

2.1.1.2 The electrical conduction system of the heart

It is the electrical activity within the heart that causes it to contract. This electrical activity starts at the self-stimulating sinoatrial node (SA) which is found laterally to the orifice of the superior vena cava [34]. A healthy heart beats in 'normal sinus rhythm' where the electrical impulse starts at the SA node and travels to the atrioventricular (AV) node and finishing at the purkinje fibres [35], [36]. The SA node is responsible for determining the frequency of the electrical impulse and hence the regularity of the heartbeat [35]. In its normal state the myocardium is electrically polarised as no electrical activity takes place [37], [38]. However, ions such as sodium and potassium surrounding the myocardium are positively charged, while the myocardial cells have a negative resting charge [29], [38], [39]. When a stimulus derived from the SA node is applied to a myocardial cell its charge is briefly altered. Thus, the cell membrane becomes selectively permeable allowing positively charged sodium and calcium ions to flow into the cell. As the cell fills with more positive ions the cell itself becomes positive, thus inducing an action potential. This action potential leads to the contraction of muscle fibres, a process known as myocardial depolarisation [39], Conversely, repolarization occurs when the electrical stimulus prevents the sodium and calcium ions from flowing through the cell membrane.

As the electrical stimulus propagates from the SA node, it generates a wave of depolarisation across the entire myocardium [38]. Beginning at the SA node the electrical impulse stimulates the left atria via Bachmann's bundle and flows down to the AV node (AV) where it briefly pauses to allow the ventricles to be replenished with blood. The impulse then travels through the bundle of His, continues to the right and left fascicular branches and finally to the purkinje fibres in the ventricles [30] [40] [41]. This electrical tract can be viewed as an electrical dipole that travels from the top-right to bottom-left and is known as the electrical cardiac axis [30]. However, it must be noted the cardiac axis changes direction during the electrical cycle as various parts of the heart depolarise and repolarise in numerous directions. It is this ordered pathway of electrical stimulation through the myocardium that provides regular contraction and relaxation of the heart. By understanding the electrical conduction system, we can assess the heart's mechanics, thus providing a diagnostic insight for clinicians. And by using the ECG to record the electrical activity of the heart, clinicians can detect a number of cardiac abnormalities [38], [42], [43].

2.1.2 The 12-lead ECG

2.1.2.1 Introduction, discovery and history of the ECG

The discovery of the ECG is attributed to Willem Einthoven who attained a Noble prize in 1925 [22], [44]–[46]. However, Einthoven was not the first to discover electrical phenomena in the heart. It was Luigi Galvani who first discovered the relationship between electricity and the twitching of muscles in a frog [47]. Almost a century later, Gabriel Lippmann used this discovery to create a device to detect electrical waves and named it the capillary electrometer. Augustus Desire Waller improved this device to record cardiac signals and created a ‘cardiograph’. He then recorded and displayed the first ECG. Thus electrocardiography was born [47], [48].

2.1.2.2 The 12-lead electrocardiogram

The ECG shows the electrical activity of the heart and is recorded using a device called an electrocardiograph. There are many ways to record an ECG, however a standard 12-lead ECG is acquired using 10 electrodes to record 12 signals, otherwise known as 12 ‘leads’ [30], Figure 2.1. A 12-lead ECG is recorded using six chest electrodes and four limb electrodes. The chest electrodes yield six precordial leads (V1-V6) and the limb electrodes yield six limb leads (I, II, III, aVR, aVL, aVF).

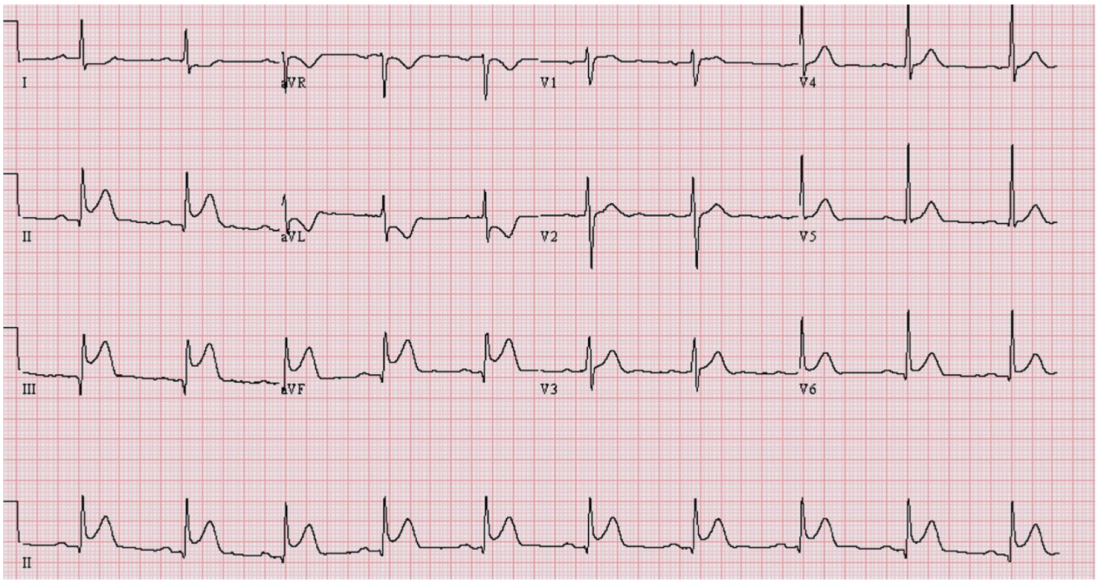

Figure 2.1: Depiction of a normal 12-lead ECG

2.1.2.2.1 Limb leads (I, II, III) and Einthoven's triangle

Einthoven's triangle can be used to assist in the explanation of how limb leads are recorded. This is in the form of an equilateral triangle as seen in Figure 2.2. An electrode is placed on each of the vertices of the triangle, i.e. an electrode on each of the shoulders with the other placed centrally over the lower abdomen. The three edges of the triangle represent the construction of leads I, II and III. Although the triangle itself is physiologically irrelevant, Einthoven derived these traces from the potential differences in voltage between the respective electrodes [30], [47].

Given each of the limb leads are derived from two electrodes, they are known as 'bipolar' leads. The polarities of these electrodes were chosen by Einthoven to give mainly positive deflections [49]. Einthoven's Law states that 'Lead 1 + Lead II = Lead III' and reflects the geometric construction of a triangle rather than any physiological valid construct. The calculations to derive leads I, II and III can be seen in Table 2.1 [50].

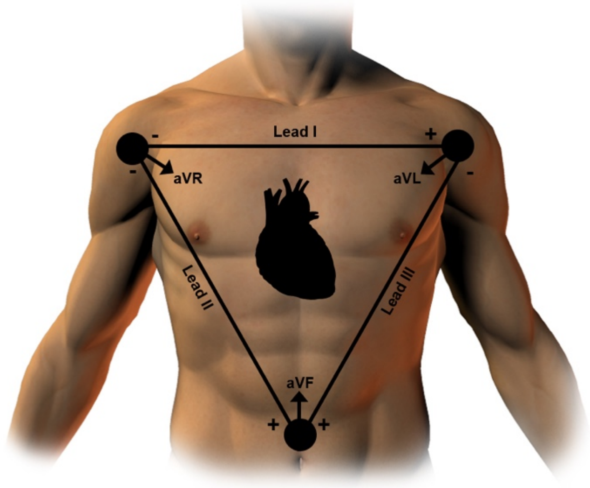

Figure 2.2: Diagram portrays Einthoven's triangle consisting of Limb leads I, II, III. The illustration also shows the direction of the augmented limb leads which were developed later by Goldberger.[51]

Table 2.1: Einthoven's limb leads, relevant equation and description

Einthoven's Lead	Equation	Description
Lead I	LA – RA (Left arm – Right arm)	Difference in voltage between the negatively charged RA and the positively charged LA
Lead II	LL - RA (Left leg – Right arm)	Difference in voltage between the negatively charged RA and positively charged LL
Lead III	LL – LA (Left leg – Left arm)	Difference in voltage between the negatively charged LA and positively charged LL

2.1.2.2.2 Precordial leads (V1 - V6) and the Wilson Central Terminal

In the 1920s, ECG interpretation moved beyond basic arrhythmia detection towards other abnormalities [52]. In 1932 Wood and Wolferth [50] made the observation that ST segment changes could be seen in chest leads. This was a significant observation as corresponding changes were not visible in the limb leads. One year later, Frank Wilson discovered unipolar chest leads and described their use in diagnosing AMI [50]. Wilson created a neutral zero reference by averaging the voltage from the three limb electrodes, which became known as the Wilson Central Terminal or WCT (WCT = RA+LA+LL)/3) [22]. Theoretically the WCT is placed in a similar region to the heart. Frohlich and Burger [53] have shown that its largest voltage does not exceed 0.3mV under normal circumstances. Hence, due to the voltage of the WCT remaining comparatively constant it can be used as a reference point throughout the cardiac cycle [54]. This allowed Wilson to use this reference as a negative pole for a range of electrodes (positive poles) to be placed on the chest [49], [54]. Hence, in 1938 the Cardiac society of Great Britain and Ireland (later the British Cardiovascular Society, BCS), along with the American Heart Association (AHA), created a standard placement for an exploring chest electrode placement. The chosen site was at the apex (V4 position). A further five sites were added to help further research. The committee stated the proposed electrode sites should not hinder further research into more appropriate positions. However, this pattern (V1-V6, ‘V’ meaning voltage) of precordial lead placement remains to this day [50]. Thus, the ECG progressed from 3-leads to 9-leads. The positions of the precordial electrodes are seen Figure 2.3 and described in Table 2.2:

Table 2.2: Description of the precise placement positions of the precordial electrodes. [55]

Electrode	Anatomical location
V1	Located on the fourth intercostal space at the right sternal margin
V2	Located on the fourth intercostal space at the left sternal margin;
V3	Located midway between electrode V2 and electrode V4;
V4	Located on the fifth intercostal space at the mid-clavicular line;
V5	Located on the same longitude as electrode V4 and on the anterior axillary line;
V6	Located on the same longitude as electrode V4 and on the mid-axillary line.

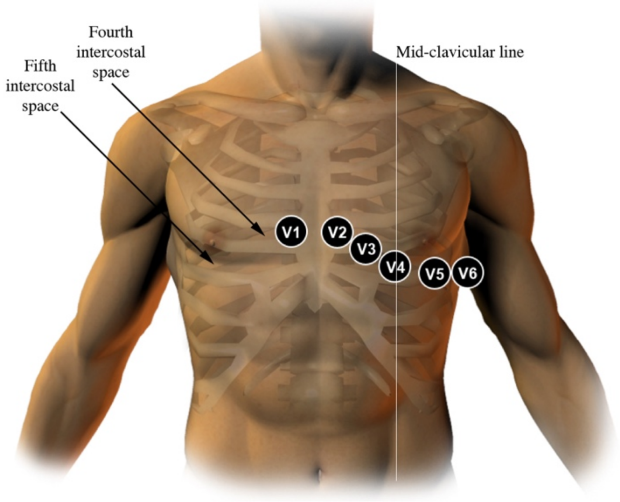

Figure 2.3: Illustration showing the precise location of the precordial electrodes placement on a human torso. [51]

2.1.2.2.3 Augmented limb leads (aVR, aVL, aVF) and Goldberger's Central Terminal

The WCT was used to derive another three limb leads, i.e. VL (Voltage Left), VR (Voltage Right) and VF (Voltage Foot). For example, VL = LA – WCT. However, the amplitudes were very small in comparison with the bipolar limb leads. Therefore, Goldberger amended the WCT and created the Goldberger's Central Terminal (GCT) for deriving these leads to exclude the respective limb lead that was being explored [30]. These new leads became known as the augmented limb leads (aVR, aVL, aVF). Hence the ECG became known as the 12-lead ECG [49], [53].

Table 2.3: Description of the equation to calculate each augmented limb lead along with a description of the lead voltage.

Augmented limb lead	Equation	Description
aVR	RA – (LA+LL)/2	The voltage recorded between the right arm electrode (positive pole) and the GCT reference ([LA+LL]/2) .
aVL	LA – (RA+LL)/2	The voltage recorded between the left arm electrode (positive pole) and the GCT reference ([RA+LL]/2) .
aVF	LL – (RA+LA)/2	The voltage recorded between the left leg electrode (positive pole) and the GCT reference ([LA+RA]/2) .

2.1.2.2.4 Electrocardiogram deflections and waveforms

The various deflections found on each lead represent specific stages in the cardiac cycle. These deflections can be categorised into five main waves: P, Q, R, S and T (Refer to Table 2.4)**.** These deflections are also often considered as components of time intervals and segments, which represent a series of larger events in the cardiac cycle (refer to Table 2.5).

Table 2.4: Description of ECG deflections alongside associated information regarding wave size and other positional data.

ECG Waves	Corresponding physiological events	Associated information
P - wave	P-wave corresponds with atrial depolarisation, which in turn results in atrial contraction.	The first half of the P-wave represents right atrial depolarisation and the second half of the deflection represents left atrial depolarisation. Atrial repolarisation is invisible because the QRS complex conceals it.
QRS complex	QRS represents ventricular depolarisation resulting in ventricular contraction.	Normal QRS width is between 70-100ms. Normal QRS amplitude: Limb leads > 5mm Precordial leads > 10mm
Q - wave	Q-wave represents the normal left-to-right depolarisation of the inter-ventricular septum.	The first negative deflection in the QRS complex.
R - wave	R-wave represents depolarization of the main mass of the ventricles.	The positive deflection in the QRS complex. Due to the R wave reflecting the largest portion of the heart it is normally the largest wave.
S - wave	S-wave represents depolarisation of the basilar potion of the left ventricle.	The second negative deflection in the QRS complex.
T – wave	T-wave portrays ventricular repolarisation, which results in ventricular recovery.	Appears on the ECG if the QRS complex is present as the heart returns to its relaxed state.
* U – wave	U wave may represent the repolarisation of the Purkinje fibres of some portion of the myocardium or by mechanoelectrical coupling.	The lack of consensus about the origin of the U wave has led to the neglect of its clinical significance. Its origin requires further research [56].

Table 2.5: Description of ECG intervals alongside associated information regarding complex length and other positional data.

ECG time interval waves	Corresponding physiological events	Associated information
PR interval	PR interval denotes the time from the start of atrial depolarisation to the start of ventricular depolarisation.	This interval normally lasts between 0.12 and 0.2 seconds.
QT interval	QT interval indicates the time elapsed during ventricular depolarisation and repolarisation.	This interval usually lasts between 0.34 and 0.42 seconds.
R-R interval	R-R interval is the length of time taken between heartbeats.	This interval bridges the gap between R deflections in multiple cardiac complexes.

Influenced by Descartes, Willem Einthoven named the waves using the letters PQRST. This accommodates other waves still to be discovered, before the P wave or after the T wave (including the later discovery of the U wave) [57]. In addition, to these waves, every 12-lead ECG tracing has a calibration wave. A calibration enables an interpreter to determine the print speed and to identify the reliability of the amplitudes. A typical calibration wave should be 25mm per second and 10mm per mV [37], [46].

2.1.2.3 Presentation of the 12-lead electrocardiogram

Today a clinician reads the 12-lead ECG on printed graph paper with its y-axis representing voltage (millivolts, mV) and its x-axis representing time taken (seconds, s). The printed graph paper comprises of small 1mm x 1mm squares that correspondingly represent 0.1mV and 40ms. Larger squares (5mm x 5mm) equate to 0.5mV and 200m [58].

The leads of the ECG are normally presented in a standard format called '3 x 4 + 1R'. In this grid format of four columns and three rows, the first column displays the limb leads (I, II, III). The second column displays the augmented leads (aVR, aVL, aVF) and the last two columns display the precordial leads (V1-V6) [59]. These segments are short showing only 3.33 seconds of data. Thus, most ECG printouts will also display a "rhythm strip" (+1R) along the bottom of the ECG paper. This will usually be a 10-second recording of lead II since it offers a good definition of the P-wave and emphasises any rhythm irregularities [37]. Figure 2.4.

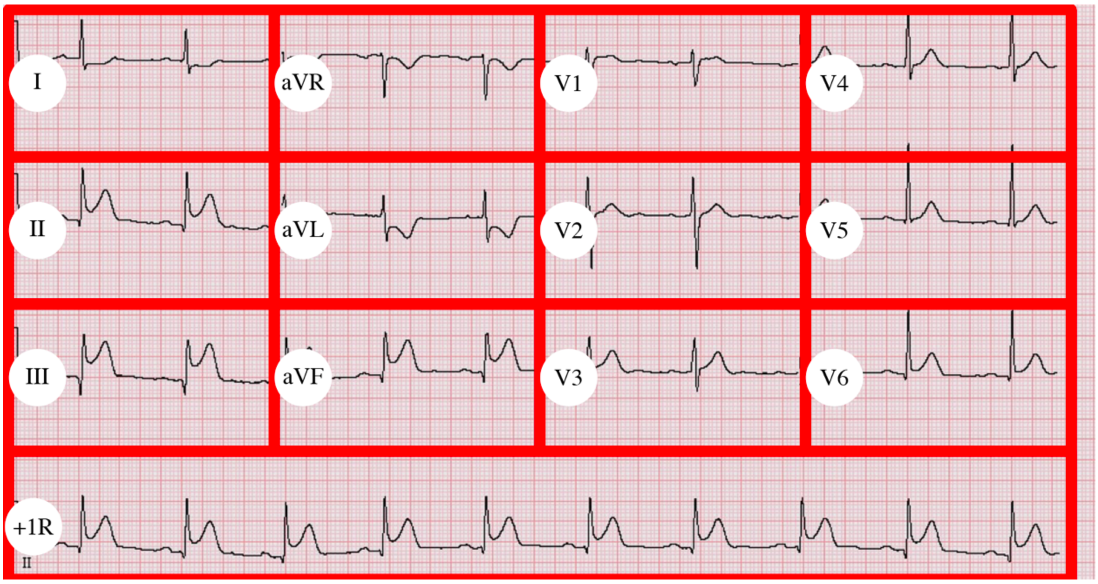

Figure 2.4: Depiction of normal 12-lead ECG including lead placement annotations, illustrating the 3x4+1R format

The 12-lead ECG has been presented and printed using this format for more than 70 years [5]. It became the 'de facto' format for clinicians given it provides a means for consistency [60], [61]. However recent technological developments have provided the opportunity to replace or enhance this approach.

2.1.3 Limitations of the 12-lead Electrocardiogram

Although electrode sites have long been chosen and standardised by both the BCS and AHA this arrangement has only limited historical significance or rational backing and have been described as sub optimal [62]. Furthermore, as the precordial lead electrode sites are very specific they can be difficult to place correctly, leading to frequent misplacement, inaccurate recordings and misdiagnoses [63]–[65]. The limb lead sites also provide difficulty in accurate ECG acquisition due to a non-standardised electrode placement. Electrodes can be placed on both the ankles and wrists as well as on more proximal regions as noted in the Mason-Likar variation [66].

2.1.4 12-lead Electrocardiogram Interpretation

The 12-lead ECG has become one of the most frequently used cardiovascular diagnostic tools and has become fundamental in clinical practice [22].
However, becoming proficient in ECG interpretation requires a considerable degree of time and effort [25]. Initial training in ECG interpretation is a common cognitive skill that is traditionally acquired during medical school via didactic teaching and self-directed learning [6], [25], [67]. This format of training then continues throughout a practicing clinicians career [6], [25], [67]. As yet, there is no standardised, best practice method for teaching ECG interpretation with given teaching formats differing considerably between practices and institutions. Teaching methods include guidance at the patient's bedside within clinical practice, lecture-based learning and computer-based learning which range in teaching styles between clinical, didactic and electronic [67].

This standardisation is highlighted by the amount of time considered necessary to become proficient, the faculty training required, and even the variability in the number of required practice ECG interpretations [46], [25], [6], [68]. Although the optimal format for the acquisition and retention of ECG interpretation skills has not yet been determined [45], it is clear that repetition is a key factor to achieving accuracy and maintaining competency in ECG interpretation [25], [6].

2.1.4.1 ECG interpretation reporting and analysis

Reporting of an ECG interpretation can be done with and without using systematic checklists. Such systematic checklists vary regarding their content and sequence of ‘checks’ depending on the institution, however they generally follow a common sequence [4], [17], [37], [69]–[72]. The typical components within ECG reporting formats have been described in the following section. The series of checks illustrated in these papers could be incorporated into a model, and form the basis of a structured, cognitively engineered, decision support system. This provision of a structured decision making process could augment the digital interpretation of the 12-lead ECG.

2.1.4.1.1 The heart rate

Given that 300 large squares on the ECG printout correspond to 60 seconds, the quantity of large squares between R deflections can then be divided into 300 to give an approximation of the subjects Heart Rate (HR) [73]. Hence, HR = 300/(large squares between R waves) = beats per minute. If the HR looks slow or irregular, the HR can be estimated by counting the number of R deflections in a consecutive six-second period and multiply this by 10 [69].

2.1.4.1.2 The heart’s rhythm

The heart’s rhythm, as distinct from heart rate, can be one of the most difficult facets in ECG interpretation as it requires a deeper understanding of electrophysiology [69]. For this reason, it is often one of the most misdiagnosed parts of an ECG when processed by a computer [74]. Rhythm analysis is frequently carried out using the rhythm strip. To carry out an accurate analysis of the rhythm, the human interpreter needs to consider the heart rate, RR regularity, P wave morphology, PR interval, QRS interval and the relationship between the P wave and the QRS complex. As yet no algorithm has been developed to process all of these components in relation to each other [69]. However, interpreting the relationship between the P and QRS complex along with the heart rate provides insight into the heart’s rhythm. Typically, heart rhythm analysis involves scanning the entire rhythm strip for pauses, premature beats, irregularities and abnormal waves. It also involves checking that a QRS complex follows each P wave, measuring the PR interval to determine heart blocks and QRS interval checks to rule-out bundle branch blocks [69], [70].

2.1.4.1.3 Cardiac axis

The cardiac axis is the mean two-dimensional vector (or dipole) of ventricular depolarisation. It is also known as the QRS axis or electrical axis [37], [60]. It is important to determine the cardiac axis as an abnormal vector may suggest a number of pathologies including right and left ventricular hypertrophy [37], [70]. The cardiac axis of the heart can be estimated using the hexaxial reference system as seen in Figure 2.5 [37], [60], [69], [75]. By splitting the hexaxial reference system into quadrants we can approximately identify the direction of the cardiac vector [76]. The cardiac axis quadrant can be determined by simply observing the perpendicular leads I and aVF. This approach is shown in Table 2.6. Alternatively, the cardiac axis can be precisely computed using Equation 1.

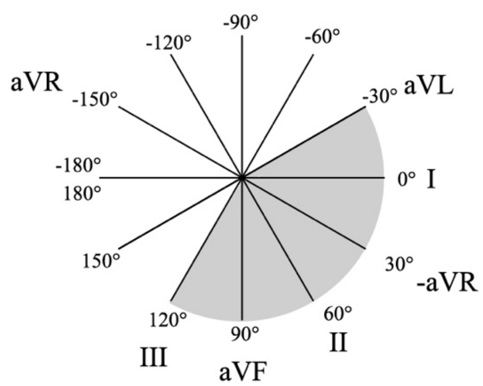

Figure 2.5. This illustration shows the hexaxial reference system developed by Caberra [49] *. The hexaxial reference sytem combines Einthoven's and Goldberger's limb leads and consequently presents the leads in 30° intervals.* [51]

Table 6. Quadrants of the hexaxial reference system to classify the cardiac axis

Lead 1	Lead aVF	Quadrant	Axis
Positive	Positive	Lower left quadrant	Normal axis deviation (-30° to 90°)
Positive	Negative	Upper left quadrant	Left axis deviation (0° to -90°)
Negative	Positive	Lower right quadrant	Right axis deviation (90° to 180°)
Negative	Negative	Upper right quadrant	Extreme axis deviation (-90° to 180°)

$$qrsAxis = \mathrm{arcTan}\left(\frac{avfRPeak - |\, avfSNadir \,|}{iRPeak - |\, iSNadir \,|}\right) \qquad (Equation\ 1)$$

The cardiac axis can also be found using an equation where the trigonometric function *arctan() is* used to compute the QRS axis in degrees when given a ratio. To derive the required ratio, the numerator is calculated by subtracting the R deflection peak in lead aVF (*avfRPeak*) from the magnitude of the S deflection Nadir also in lead aVF (*avfSNadir*). The denominator is then found by subtracting the R deflection peak in Lead I (*iRPeak*) from the magnitude of the S deflection nadir (|*iSNadir*|) in lead I. Once this ratio has been found it can be used in the arcTan trigonometric function and hence will provide the mean electrical axis the myocardium muscle [77].

2.1.4.1.4 Conduction times

Following calculation of the cardiac axis an interpreter typically interprets the conduction times of the deflections. Normal P wave duration should < 0.12s with amplitudes < 2.5mm. The PR interval should be between 0.12s and 0.2s. Normal QRS complex duration should be 0.1s. The QRS amplitude in a normal ECG >5mm in the limb leads, and >10mm in the precordial leads. The QT interval is usually lasts between 0.34s and 0.42s. However, due to the variance of the QT interval depending on the heart rate this measurement needs to be corrected. This can be achieved using Bazett's formula, Equation 2 [78]:

$$\mathrm{QTc} = \frac{QTinterval}{\sqrt{(R - R\ interval)}} \qquad (Equation\ 2)$$

2.1.4.1.5 Morphological aspects

Any deflection morphology changes are then assessed including P wave, QRS complex and the ST segment. For example, ST segment elevation/depression is considered. The ST segment should normally be equiphasic but it may be elevated or depressed. ST elevation can highlight AMI or pericarditis whereas ST depression can indicate the early signs of ischemia [37].

2.1.4.1.6 Conclusive diagnosis

Lastly, the interpreter is required to provide a final diagnosis. This last portion of the ECG reporting process is vital as it confirms the previous interpretations made concerning the hearts rate, rhythm, axis, conduction time and morphological aspects.

2.1.4.2 Approaches to learning electrocardiography and ECG reporting procedures

Standardisation for teaching ECG interpretation has not yet been defined. Fent et al. [25] conducted a study to determine which method of teaching ECG interpretation was best. He found no clear superior method of instruction. However, self-directed learning was proven to be a weaker form of learning when compared to lecture-based learning. This was highlighted in both post-course test scores and in the retention test. Findings also indicated that "assessment drives learning" where summative assessment out-performs formative assessment. Fent et al. signified how web-based learning packages illustrate the greatest possibility for improving the future of ECG interpretation teaching due to much greater interactivity and accessibility. However, a warning was offered owing to the challenge of ensuring the content delivered was accurate and of high quality [79]. Based on a 2005 US survey of Clerkship Directors in Internal Medicine the preferred methods for teaching ECG interpretation to medical students was lecture-based teaching (75%) [80]. Other preferred teaching methods included mentorship at the patient's bedside during clinical practice (teaching rounds), lecture-based learning and computer-based learning which range in teaching styles between clinical, didactic and electronic [25], [67].

Rui Zeng conducted a study that involved teaching using the "graphics-sequence memory method" otherwise known as systematic interpretation. The graphic sequence approach uses a similar reporting process as mentioned above except it includes an initial phase comprising of schematic diagrams to illustrate normal and abnormal ECGs, thus allowing the interpreter to clearly understand an ECG abnormality [4]. This encourages pattern recognition and the memorisation of ECGs. Traditionally, when students are taught to detect AMI they are first presented with a number of ECGs that exhibit obvious AMI abnormalities. This method is also known as disease-based teaching and has been found to be sub-optimal for correctly identifying diseases. This study [4] highlighted that a graphics-sequence approach complemented with schematic diagrams are useful for helping students remember key aspects. This approach improved the accuracy of ECG interpretation from 43%, when using the traditional approach, to 77% using the graphic-sequence method. Chinese instructors found that teaching traditional ECG interpretation was a difficult process [4]. This is due to the typical intricate concepts contained within the ECG including the abstract nature of the required theoretic knowledge, its scattered characteristics and its arduous memory-intensive subject matter. Thus, students find it difficult to learn. The study states that by knowing the clinical symptoms of the subject students will develop an understanding of 'why' the ECG is presenting specific morphologies rather than only knowing the definitions of the abnormal waveforms. This in turn hinders the default rote learning approach to ECG interpretation and helps the student better fully understand the electrical cardiac state of a patient [4].

2.1.4.3 ECG interpretation in clinical practice

Studies have emphasised that 33% of ECG interpretations have errors of significant importance [61], [6]. It is commonly recognised that medical image interpretation follows a two-stage process – initial perception followed by clinical decision-making [8], [16], [81], [82]. Wood et al. [17] identified how experts detect abnormalities almost immediately when presented with an ECG that does not conform to the morphology of a normal ECG. Abnormalities are identified almost immediately and are inspected further using foveal vision. Foveal vision is the use of the central retina, which provides maximal visual resolution. Contrastingly, novices who have not yet built up a knowledge base for pattern recognition cannot utilise the ability perform a Gestalt analysis of the ECG. Thus, they adopt a structured step-by-step approach to ECG interpretation. This requires the use of energy intensive foveal vision to search and analyse each step for abnormalities [82]. To achieve these findings Wood et al. utilised the Applied Science Laboratories (ASL) mobile eye gaze registration system [83], which monitors and records a person's fixations without restricting head movement. This data was then analysed using ASLs Gazetracker software, which provided the ability to acquire search rate data and hence analyse the subjects' number of fixations per second. Similarly, specific areas of interest could also be defined and termed 'lookzones' as they became the areas with most fixations and thus enable the critical leads to be identified. It was found how experts were twice as accurate, twice as quick and 1.5 times more confident than their novice counterparts. As the same scanning process was used between both cohorts this study highlights how an experts discriminatory strategy, developed from previous experience, provides the capacity to identify critical information and ignore less relevant information on a 12-lead ECG.

Bond et al. corroborated the results found by Wood et al. in an eye tracking study. This study used the Tobii X60 eye tracker enabling the ability to record the eye gaze of ECG interpreters [84]. The paper underlines a strong correlation between the age of an ECG interpreter and accuracy as expected. However, surprisingly only a moderate correlation was found between experience to accuracy. Bond also acknowledged how experienced ECG interpreters adopt an approach to interpretation based on their initial first impression and pattern recognition, while novices utilise a strict protocol to systematically interpret the ECG [85]. It was also identified how experts revert to a systematic approach to interpretation if their first impression proved inconclusive. However, following successful identification of an abnormality via an initial perception resulted in co-abnormalities being overlooked. This led Bond et al. [85] to recommend that ECG interpreters adopt a strategy that begins with initial perception but is always followed up by a conventional systematic protocol, thus providing a method to identify co-abnormalities and to avoid 'early satisfaction syndrome' in the reader. This study also found that leads V1, V2 and the rhythm strip are typically viewed first and for the longest duration. Also, noted in this study was the inconsistent terminology used when reporting ECG interpretations, e.g. experts were referencing atrial hypertrophy or atrial enlargement. This again stressed the lack of standards attributed to ECG interpretation, and as a result 90% of subjects encouraged the creation of best practice guidelines for the process of ECG interpretation. Recommendations for the standardisation of ECG interpretation has begun but has yet to be adopted due to institution independency agreement and varying diagnostic criteria [85].

Richard Jabbour at St Mary's Hospital, London, has developed a further variation of the ECG interpretation reporting process [86]. Having observed the lack of ECG interpretation knowledge in medical and nursing professionals [87], Jabbour constructed a systematic framework for ECG interpretation to assist novices in reading an ECG. Most ECGs are read by non-cardiologists with junior doctors interpreting up to 30% of ECGs incorrectly [88]. With a heavy influence on clinical value in ECG interpretation, Jabbour, like Zeng, highlights how it might be easy to miss a lesser abnormality in an ECG due to the high amount of theoretical knowledge and memorisation of the subject matter required to evaluate one tracing. This, in combination with the typical scattered characteristics of an ECG, it may be easy to overlook an abnormality. It must also be noted that an ECG without visible abnormalities does not discount the presence of a pathology being present in a patient [21]. Therefore, patient details and clinical state are a vital component in the ECG interpretation and overall diagnostic process. It is for this reason that machine-interpretation of ECGs should still be over-read and verified by a clinician who takes into account the other clinical aspects of the patient [12], [48]

To help non-cardiologist practitioners, [89], Jabbour developed the C.R.A.S.H mnemonic which stands for a five-step process: Clinical, Rhythm, Axis, Sequential reading and Hypertrophy. Starting by assessing the subject's context followed by assessing the heart rate and rhythm and the cardiac axis. Sequential-reading uses a novel method to help interpreters understand where the electrical impulses in the ECG originate. This is achieved through the use of a coloured overlay, using the four colours red, green, blue and yellow. These four colours correspond to the electrical view of the heart that each lead offers. The lateral view of the hearts comes from Lead I, aVI, V5 and V6 (seen using yellow), whereas the leads aVR an V1 represent the electrical view from the right side of the body (red). The three anterior leads, V2, V3 and V4, show the heart from the front of the body (blue) and the inferior leads (lower) Lead II, Lead III and aVF are represented in green. This overlay is to help stimulate rational thought in the practitioner by helping them understand the relationship between the electrical viewpoints of the heart and their individual significance. The final stage (the H) represents checks for cardiac hypertrophy (enlargement of cardiac tissue).

Rose Hatala [90] also demonstrated the strong and consistent effect the clinical state of a patient has on the accuracy of ECG interpretation. This was established for clinicians at all levels of training. However, Hatala discovered how the effect of clinical history works both ways. Hatala found diagnostic accuracy improved when the subject's history implies the correct diagnosis but the accuracy was reduced when the patient's history suggests a misleading diagnosis. Thus, it is clear that clinical history influences an interpreter's opinion and has a bidirectional effect [90].

2.1.4.4 Challenges of 12-lead electrocardiogram interpretation

As cardiac abnormalities often manifest in the 12-lead electrocardiogram it is often used extensively. However, due to its complexity, it often leads to frequent misinterpretation [38], often containing errors of significant importance [91], with diagnostic accuracy having been reported as being as low as 40% [92]–[94].

2.1.4.4.1 Difficulty in interpretation

Due to the complex nature of 12-lead ECG interpretation including analysis of multifarious leads, deflections and patterns, a significant cognitive workload is required from the interpreter [95]. This is in addition to the interpreter having to refer to an intricate knowledge-base in cardiac pathology and cognitively cross-referencing a large set of ECG criteria. Therefore, it is of typical expectation that students, teachers and even experienced clinicians find the ECG difficult to interpret and could lead to errors in diagnoses and treatment [4].

This overload of information, from background knowledge to the complicated presentation of a 12-lead ECG, can have a detrimental effect on the cognitive thinking process. A human working memory has a predetermined capacity, and thus by assimilating large numbers of variables, comprising of 12 leads, multiple complexes, numerous deflections and assistive computational data, it is obvious that the human cognitive ability will deplete rapidly [95].

Consequently, it is of paramount importance for experts to lower the cognitive load forced upon an interpreter when the opportunity presents itself through the upcoming digitisation process. Furthermore, the retention of ECG characteristics and subject matter is also a difficult task when interpretation is not part of daily activity and hence the erosion of knowledge over time can be a significant factor in ECG interpretation accuracy [67], [96].

Proficiency in ECG interpretation requires a considerable degree of skill [25]. Initial training in ECG interpretation is acquired during medical school usually via didactic teaching and self-directed learning [6], [25], [67]. However, there is no standardised best practice methods for teaching ECG interpretation given teaching formats differ between institutions. Teaching methods can include guidance at the bedside within actual clinical practice, lecture-based learning and computer-based learning [67]. This is even highlighted through the variability in the number of ECG interpretations required to become proficient [46], [25], [6], [68]. Although the optimal format for the acquisition and retention of ECG interpretation skills has not been determined [45], it is clear that repetition is a key factor to achieving and maintaining competency [25], [6].

Definitions of requirements to become a competent ECG interpreter are wide ranging with varied guidelines and recommendations [6], [7]. The American College of Cardiology (ACC) and the AHA recommends that a minimum of 500 ECGs must to be interpreted during training, while supervised, to become competent. This is a revised number from a previous edition citing 800 interpretations were required for competency. However, both figures are solely based on expert opinion rather than evidential empirical data [46], [97]. To maintain this interpretation competency they recommend an annual interpretation rate exceeding 100 ECGs [46]. These figures differ regularly depending on accrediting association and date of publishing. For association fellows, the cardiovascular diseases review committee for the Accreditation Council for Graduate Medical Education Residency has determined the minimum number of supervised interpretations to be in the region of 3500. While they have not provided a figure for accrediting internal medical students, a survey of programme directors suggested that an average of only 100 interpretations are required [61], [6] . Salerno et al. identified that although many organisations highlight the importance of ECG interpretation they state that there is insufficient data to confirm how competency should be achieved [26].

This leads to the awareness that ECG interpretation may require its own qualification. Predictably, the American boards of Internal Medicine and Emergency Medicine require training in electrocardiography to allow a clinician to assess chest pain or cardiovascular instability. However, a national standard has not been created to outline, or gauge, competency in ECG interpretation. Hence only 21% of American emergency medicine programmes test for competency in ECG interpretation [98], [99]. The ACC and AHA highlight that physicians can achieve board certification by passing a separate cardiology examination. Nevertheless, some physicians who are not board-certified in cardiology can still become electrocardiographers by interpreting over 500 ECGs under direct supervision of an expert electrocardiographer [46]. The Core Cardiology Training Symposium (COCATS) [100], [68] published the recommended training requirements for adult cardiovascular medicine in the Journal of the American College of Cardiology in 1995 [88], and has since been updated [68]. Significantly, it identifies that there is no established landmark for ECG interpretation training, but states that interpretation of between 3000 and 3500 ECGs in a 36-month period should provide the adequate experience required to develop these competencies. However, literature suggests that when compared to an expert's interpretation, approximately 100 million (or 33%) of ECG interpretations per annum contain an error. Eleven percent of these interpretations resulted in patient mismanagement. With 1% of these interpretations resulting in significant adverse mismanagement, consequently causing pain or potential death (1,000,000 people) [6]. To combat this issue, in 2001, the ACC and AHA in 2001 stated that the ECGs interpretation should be entirely interpreted conducted by either a cardiologist or a physician whom has demonstrated competency through an examination exam process such as the ECGEXAM as set by the Institute of Clinical Evaluation (ICE). However, ICE has since been disbanded leaving a vacuum in ECG examination. As a result, less competent physicians without sufficient training, are being required to perform to the 'best of their ability' [61].

To corroborate, the Society of Cardiological Science and Technology, and supported by the British Heart Foundation, identify that until recently there has been a lack of nationally recognised qualifications in ECG recording and interpretation [87]. This is dramatically emphasised through results in studies which demonstrate only 19% of nurses can correctly identifying myocardial ischemia [101] and, there is widely varying competence levels amongst junior doctors [102]. For example, 33% of junior doctors regularly misinterpret ECGs (with 21% directly resulting in patient mismanagement) [88]. A large Danish study also highlights how General Practitioners (GPs) are being out performed by ECG machine interpretative programs in detecting ECG abnormalities [103]. Confidence levels amongst GPs in ECG interpretation have also been found to be low in the north-east of England [104]. As primary caregivers, a GP's confidence and competency in ECG interpretation is essential [67]. These findings illustrate the need for a national, and international, qualification in ECG interpretation.

2.1.4.4.2 Variability in ECG interpretation

Cardiologists do not always agree in their interpretations of the same ECG as found in an interpretation competency study by Salerno et al. [6]. This was revealed through interpretations of ST-segment elevation (k = 0.05), ST-segment depression (k = 0.38) and a normal ECG (k = 0.42) providing evidence of poor agreeability. Other results regarding T-wave inversion (k = 0.63) rated highly, and it was noted that the level of agreement may be greater for more severe abnormalities. Therefore, the concept of creating a 'Gold Standard' for ECG interpretation in the future could cause concern due the experts diverging on definitive final interpretations. Bond et al. further confirmed this in an eye tracking study where it was found that a moderate degree of interpretation variability was present between ECG interpreters [8]. This moderate inter-observer reliability among interpreters ($P_a = 0.56$) was revealed using the Fleiss' generalised kappa coefficient.

2.2 Computer-based decision support in ECG interpretation

2.2.1 Clinical decision making

Clinical decision making is a complex and contextually dependant process [105]. Many cross-domain factors can guide a clinical decision, as illustrated by Smith et al. when discussing factors influencing physiotherapy decision making, and presented in Figure 2.6. This figure concisely illustrates the interlinking factors which influence a clinical decision, irrespective of domain. Clinical influences are often present at the point of care; patient symptoms and a clinician's knowledge base (ranging from working memory to long term memory, but also including external sources e.g. textbooks). However, non-clinical influencing factors typically fall into two categories, professional constraints (including policy, time and expenses) and patient/practitioner personal factors (including cultural or personal beliefs/values, personal experiences and socioeconomic status, quality of life, patient expectations and practitioner characteristics) [106], [107]. The clinical decision making process is known to have two classifications; intuition and rational thinking [108].

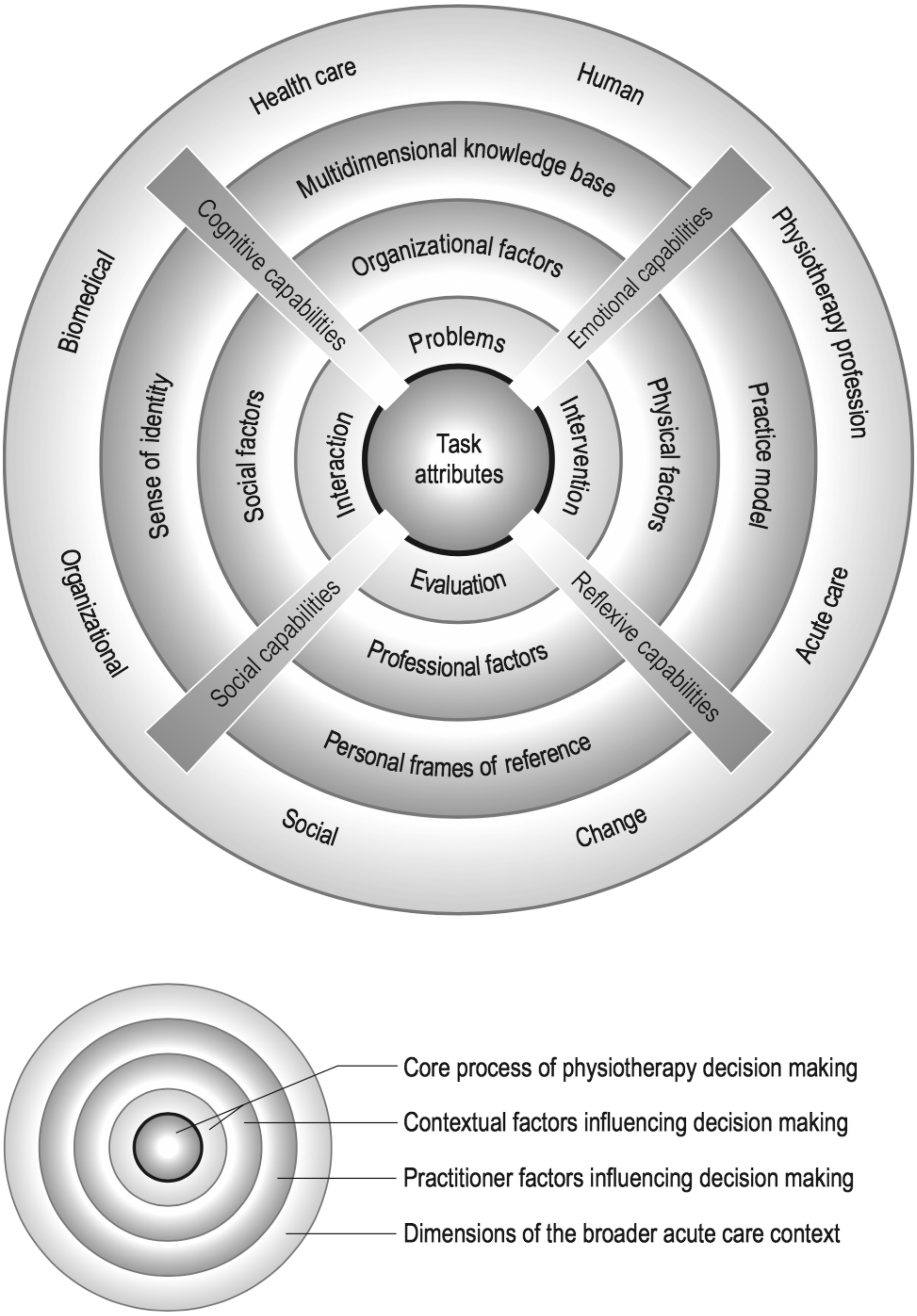

Figure 2.6. Factors influencing physiotherapy decision making in an acute care setting. From [107].

2.2.1.1 Intuitive cognition

Intuition, as a method of decision making, was initially identified by Carper et al. [109] in 1978 while seeking to understand how nurses make decisions. Intuition has been outlined as “Understanding without rationale” [110]. However, a number of other definitions have been suggested as some authors differ on the concept of intuitionism, these include “a perception of possibilities, meanings, and relationships by way of insight” [111], “immediate knowledge of something without the conscious use of reason” [112], “process whereby the nurse knows something about the patient… of which the source of knowledge cannot be determined” [113] and “lacking underlying conscious processes and as not being able to be explained in a tangible manner” [114], among others.

Intuition has been notably associated with previous clinical experience with experts behaving differently to novice interpreters. Benner noticed how novice nurses followed analytical principles to guide their actions whilst experts seemed to abandon this approach and default to a more intuitive process [115]. This intuitive approach being propelled by the context of the presenting situation in which experts are more reactive to presenting anomalies or outliers, “In effect, experts know when to break the rules” [115]. This has been corroborated by experts in a range of medical fields including Elastography [116], Tomography [117], Echocardiology [118], Ultrasound [119], Spectrometry [120], Radiography [81], [82] , and as previously reported, in Electrocardiology by Wood et al. [17] and Bond et al. [8]. Interestingly, Thompson et al. [121] determines that clinicians who exercise intuition in the decision making process find themselves being the driving force behind an interpretation, rather than focusing on clinical evidence. He suggests motivations for subconsciously adopting this approach may result from task complexity or the cognitive workload expected.

Heuristics, a general term used to describe an approximation solution dependant on exchanging accuracy, completeness and precision for speed, has also been used as an alternative description for intuition [114], [122]. Muir et al. identifies “shortcuts are created so that only certain cues are identified among huge amounts of information” with Cioffi et al. [114] suggesting these shortcuts could be based on previous experiences, with nurse recalling a familiar pattern. Buckingham and Adams et al.

[122] corroborate this theory stating that pattern recognition may occur at a subconscious (decisions made which are not currently in focal awareness), or even unconscious (decisions occurring automatically and are not available for introspection), level, while continuing to state how analytical reasoning occurs consciously.

There are a number of issues when this method of decision making is used unaccompanied. Namely, the rationale for a decision is only perceived by the decision maker [121], explicatively in clinical decisions may be absent and therefore could be received as guesswork [121], justification for decisions (especially erroneous decisions) will be either unavailable or insufficient [121]. Nevertheless, intuition has proven to be both useful, accurate and a vital part of clinical judgement. Benner [110], [115] Cioffi [114] and Wrubel [123] all highlight the accuracy of intuitive judgement when predicting risk in patient care. However, the "cold rationality" of a systematic approach in CDSS is compelling to both clinicians and performance evaluators [121].

2.2.1.2 Critical cognition

Analytical thinking refers to a clinician's systematic approach to preforming any given task. A user would typically follow a protocol, or set of rules, to task completion. This thought process classification is based in information processing theory [124]. This theory states a decision-maker stores relevant information with the decision-making process then retrieving this information from both short term and long term memory when required. Although long term memory has a greater storage capacity it can be more difficult to recall. However, Fonteyn and Ritter illustrate how clinical experts can retrieve information stored in long-term memory by using cues, or instructions, stored in short term memory [124]. This theory is the basis of numerous decision making models including Carnevali and Thomas [125] which follows a seven-stage linear approach from exposure to the problem, through forming an explanation, to a final diagnosis. Carroll and Johnson offer another, more flexible, seven-step information-processing model which allows decision-makers to refer to each stage in a non-linear fashion, or repeated when necessary [126].

To use the information stored in both long term memory and short term memory often protocols are implemented, such as decision trees or checklists. Checklist protocols have been proven to improve accuracy and reduce diagnostic error in clinicians [95]. Simultaneously, checklists also enforce critical thinking and re-examination of all relevant information presented to a clinician [95], [127].
Some concerns have been raised about adding to the plethora of information required to be processed by a clinician. Nevertheless, critically, a checklist led interpretation (when used with familiar variables), has been found to improve expert diagnoses, did not increase cognitive load forced on an interpreter and did not contribute to expertise reversal [95]. The use of checklists does increase verification time by 12% and also marginally increases entire diagnostic time compared with experts systematically interpreting without the use of prompts [95].

Comparatively, decision-trees are more flexible, allowing features to be bypassed when unnecessary, thus allowing for a more rapid interpretation in situ. This sequence of decisions allows clinicians to guide their decision making process towards features of concern [128]. Decision accuracy in practice also improves with use of decision trees as conveyed by Dowding and Thompson [129]. Accordingly, this method of decision making is particularly prominent within NHS Trusts [128].

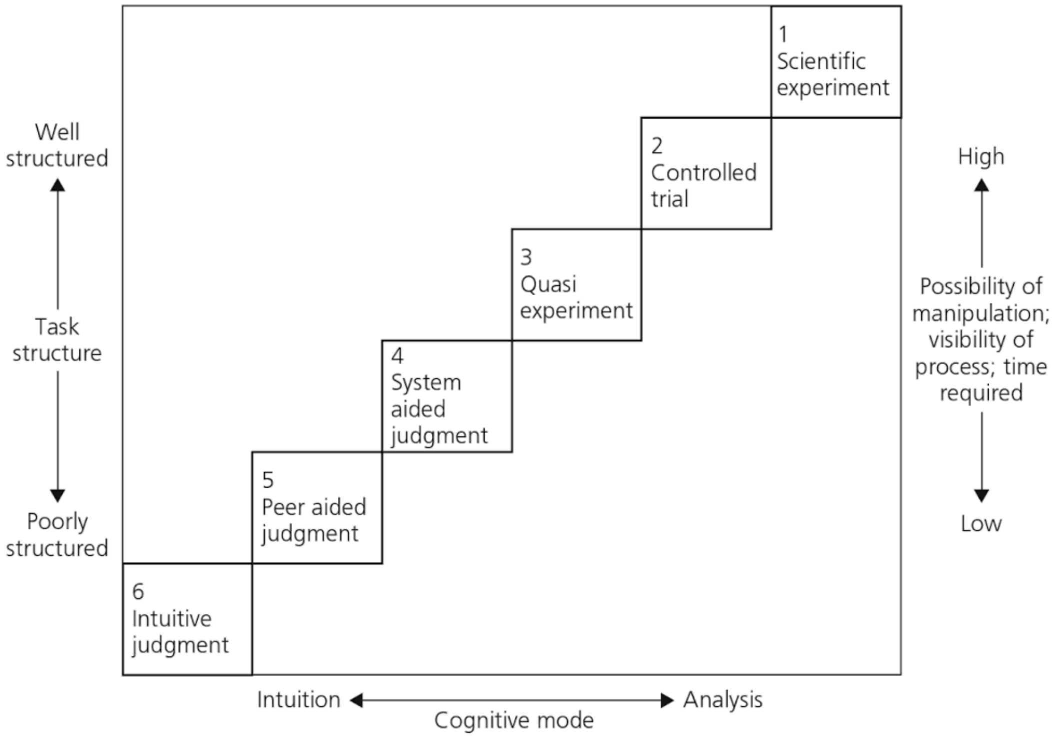

Figure 2.7. The Cognitive Continuum Theory developed by Hamm et al. [108]

Systematic analysis is typically taught as part of medical image examination training [37], [70], [79], [130][4] and is recommended to be used throughout a clinicians career [131]. However, as experts often rely on intuition, systematic analysis is typically performed by novices. This process is tiring, time intensive and can be prone to errors (forgetting sequential steps) [17]. This process of applying a systematic protocol to a situation has been used extensively in many disciplines. Atul Gawande et al. extensively illustrates the benefits of checklists have especially in a surgery environment, but also in a number of other fields including aeronautical scenarios and architectural frameworks [132]. The implementation of these paper based protocols (checklists and decision trees) are often termed clinical decision support protocols/non-digital systems [128].

2.2.1.3 Combining intuitive and critical cognition

Hamm et al. developed the Cognitive Continuum Theory [108] to illustrate influences on cognitive decision making, as illustrated in Figure 2.5. As pattern recognition is forming "judgement on the basis of a few critical pieces of information" it can be a key component in both intuitive thinking (experts subconsciously recognising abnormalities and forming conclusions) and critical thinking (where clinicians explore the entire situation attempting to find abnormalities within a sequential process) [128]. Pattern recognition develops over time as an interpreter becomes more experienced with recognised patterns multiplying, expanding and becoming more refined [128]. Developing this perception expertise contributes to clinician self-confidence increasing and an amplification of self-assessed competence [133]. Both intuitive and critical cognition are often highlighted when referring to clinical decision making in electrocardiology. Many studies identify that the most appropriate approach follows a two-stage process in medical image interpretation - initial perception followed by clinical decision-making [64], [65], [66], [67].

Nevertheless, the human-based clinical decision making (CDM) process does have flaws. Cognition relies heavily on cognitive capacity (memory available within a clinician) [128]. Another important limitation of the human cognition is its pre-set disposition to conform to a number of cognitive biases including (1) anchoring bias (fixation on a premature suggestion/answer/diagnosis/interpretation) (2) confirmation bias (seeking features/annotations to confirm rather than falsify a diagnosis) or (3) premature closure (acceptance of a diagnosis before verification). Therefore, the memorable patterns/interpretations are recalled most easily [134], [135].

This leads to the superior "cold rationality" of a computerised CDSS becoming an appealing prospect. Nevertheless, any computerised, data-processing or machine-learning based CDSS that acts as an adjunct to ECG interpretation must conform, or at least consider, these nuances in the decision-making process.

2.2.2 Clinical decision support systems

Originally, novice commentators hoped clinical decision support systems (CDSS) would be created to 'make the correct decision' in a clinical situation, with a clinician acting upon the relative result [136]. However, even in the first recognised clinical study on CDSS, the authors illustrate and comment their "method in no way implies that a computer can take over the physician's duties" [24] . They continue, stating the "use of computers are intended to be an aid to the physician" but that the "physician's task may even become more complicated" [136]. As the potential complexity and lack of accountability within CDSS became more apparent the notion of a CDSS migrated to an augmentation tool to assist the clinical choices made by a clinician. By using CDSSs in this manor a clinician can exploit both empirical knowledge of a situation and potential prognostic criteria, in a process which can out-perform both a clinician or a CDSS independently and is recommended almost exclusively in studies comparing CDSSs and human interpretation [6], [22]–[26]. To achieve this, a CDSS typically provides a suggestion(s) for a clinician, of which the clinician uses their clinical judgement to interpret these results, select pertinent information and discount erroneous suggestions.[20]

2.2.2.1 Classification of decision support systems

As previously illustrated, the limitations of human cognition have led to the development of manual and computerised DSSs. Classifications of computerised decision support systems fall into two categories; knowledge based DSS (sometimes referred to as data-driven) and non-knowledge based DSS.

2.2.2.1.1 Knowledge based decision support systems

Knowledge based decision support systems, also known as expert systems, consist of a knowledge base which examines, filters or searches data to provide a result which supports a clinical decision [137]. A knowledge based system is composed of three components; 1) the knowledge base (IF-THEN rules), an inference engine (data e.g. patient data, clinician annotations or diagnostic criteria), and a mechanism to communicate (user interface).

The inference engine within a knowledge based CDSS links recognised diagnostic rules, stored with the knowledge base, with patient or subject data to generate results. This engine acts as an intermediary between a user's request interface, a data acquisition mechanism and known diagnostic criteria. Refer to Figure 2.6.

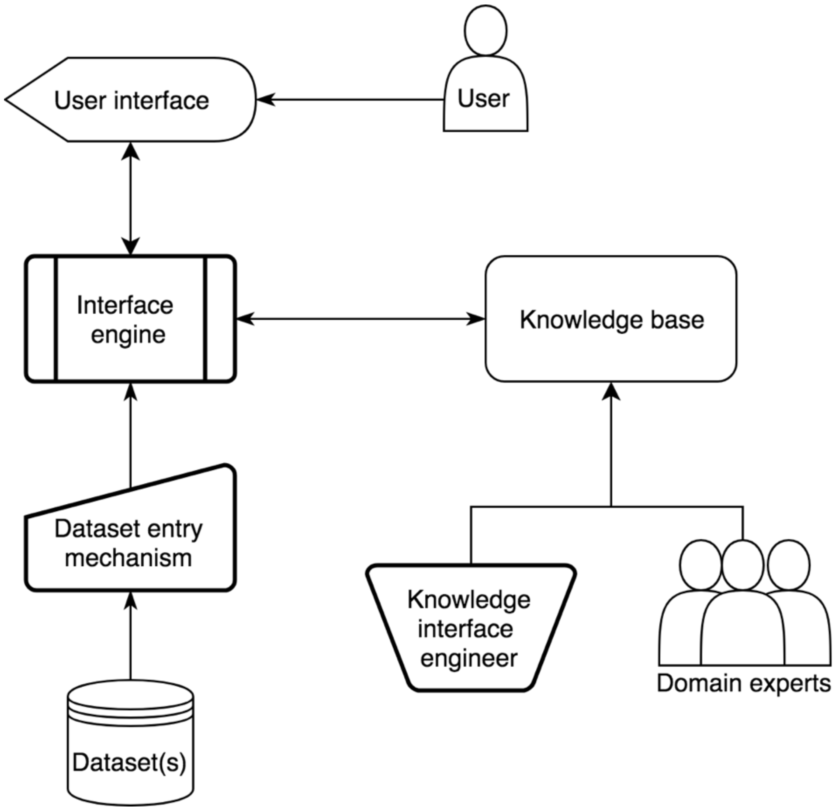

Figure 2.8. Knowledge based decision support system architecture

Knowledge based expert systems developed in the 1970s from procedural code [138] are recognised to be one of the first effective forms of artificial intelligence (AI) [139]–[142]. By the early 1980's the knowledge base was recognised as the most valuable component in the system and was key to the success of the tool [143].

There are many variations in knowledge base models, including; forward chaining, backward chaining [144] and action-selection mechanisms [145]. As algorithms progressed, a number of conceptual techniques and considerations needed to be made within various types of inference engine models, these often include; 1) truth maintenance (when primary rules are altered, corresponding dependent rules are adjusted accordingly), 2) hypothetical reasoning (the ability to explore multiple hypotheses in parallel), 3) fuzzy logic (associating the probability of the knowledge base rule being accurate with the rule itself) [146], [147]. The main disadvantage of creating a knowledge based CDSS is the difficulty in acquiring accurate, congruent knowledge from domain experts.

2.2.2.1.2 Non-knowledge-based systems

Conversely, computerised CDSS which do not use a knowledge base use a form of Artificial Intelligence (AI) known as machine learning. Machine learning algorithms enable computer programs to 'learn' from previous example material or past experiences to find patterns, anomalies or deviations in data. Although this method of decision support offers the opportunity to bypass the need for experts to input rules it cannot provide explicit rationale for the conclusions it generates as machine learning reasoning is not always easily human discernible. This is illustrated in an example provided by Dr David Weinberger "For example, you give a machine learning system thousands of scans of sloppy, handwritten 8s and it will learn to identify 8s in a new scan. It does so, not by deriving a recognizable rule, such as 'An 8 is two circles stacked vertically,' but by looking for complex patterns of darker and lighter pixels, expressed as matrices of numbers—a task that would stymie humans." [148]. Therefore, for accountability reasons they are rarely directly used in clinical scenarios [20]. However, they can be applied to post-diagnostic assessment of patients to highlight areas of interest which maybe flagged due to the patient showing variation from previous clinical records or other patients. Machine learning algorithms can also be used to illustrate overarching patient and clinician trends [20]. Like knowledge based CDSS there are various types of non-knowledge based systems that utilise different machine learning techniques, including; 1) support vector machines, 2) artificial neural networks, and 3) genetic algorithms to name but a few [149].

2.2.2.2 Clinical decision support systems in healthcare

Clinical decision support systems are used for various purposes within a large spectrum of areas, domains and specialities in healthcare, examples include; ISABEL

[150], [151] , MYCIN [152], and QMR [143]. In 1999, Perreault and Metzger [153] outlined four key domains a CDSS could serve; "

1. Administrative: Supporting clinical coding and documentation, authorisation of procedures, and referrals.
2. Managing clinical complexity and details: Keeping patients on research and chemotherapy protocols; tracking orders, referrals follow-up, and preventive care.
3. Cost control: Monitoring medication orders; avoiding duplicate or unnecessary tests.
4. Decision support: Supporting clinical diagnosis and treatment plan processes; and promoting use of best practices, condition-specific guidelines, and population-based management. "

In clinical decision support, CDSS's have been developed for decades to assist clinicians at the point of care [20]. To achieve this, CDSS augment the clinical decision process of a clinician by facilitating analysis, displaying patient data, and perhaps suggest diagnoses [20].

In 2005, a systematic review on the effects of computerised CDSS on practitioner performance and patient outcomes was conducted. This review found that patient outcomes improved in 13% of studies when decision makers used a CDSS. Practitioner performance also improved in 64% of studies [154]. A second review corroborates these findings and found that 68% of trials showed that decision support systems improved clinical practice [155]. Both reviews illustrate potential features of success, these include; user workflow integration, CDSS's are electronic, CDSS are most useful at the point of care, and recommendations are prompted – not just patient assessments. However, some systematic reviews are not as optimistic having concerns with the difficulty in CDSS evaluation, cost effectiveness and one study finding that CDSS integrated with Electronic Health Records (EHR) did not affect mortality rates [156], [157].

2.2.2.2.1 Challenges for CDSS

As with all healthcare systems there are a number of challenges which need to be considered and overcome to create a successful CDSS.

2.2.2.2.1.1 Complexity

One such challenge to overcome is the complexity in human biological systems. For example, to create a CDSS which acts as an assistant to support diagnoses of Acute Myocardial Infarction (AMI), an extensive list of patient details may need to be assessed including; any current patient symptoms, patient's scenario (i.e. was the patient recently involved in strenuous activity e.g. playing sport), patients medical history, patient family medical history, historical, geographical, racial or ethnic trends, a working knowledge of the cardiovascular system and a working understanding of the ECG morphologies – including normal and abnormal markers for AMI. Any system which aims to act as a full stack diagnostic assistant would be required to assess and present information to a clinician which simplifies this complex list of considerations.

2.2.2.2.1.1 Workflow integration

A clinician's time is already limited. Any CDSS which aims to be accepted in regular practice must fit seamlessly into a clinician's typical workflow. It must decrease diagnostic time (or at least match a clinician's typical diagnostic time), provide a significant improvement in accuracy and provide an appropriate level of prompts and warnings.

2.2.2.2.1.1 Maintenance

Maintaining a CDSS with cutting-edge, correct clinical research which is published continuously is one of the key challenges facing CDSS developers [158]. Each year thousands of clinical studies are conducted and results are published [159]. Each publication must be manually read and evaluated for merit, contrasted with other published findings, and eventually integrated into the system in a valuable way. Technological maintenance must also be considered including development time, costs and appropriately structuring legacy systems [63], [158], [159].

2.2.2.2.1.1 CDSS evaluation

It's often difficult to contrast various CDSSs with a single metric due to their diverse application and different objectives. However, it is clear a CDSS must improve a clinician's workflow and a patients overall care. To evaluate these systems, they are often analysed for consistency and accuracy against themselves, other CDSS and domain experts [161]. Nevertheless, these methods can have limitations. Due to the 'messy' and complex nature of decision making regarding the human body - "decision support is most often applied to simple, easily structured problems" [121].

2.2.2.3 Clinical decision support systems in electrocardiology

The ECG has been visually analysed by cardiologists in the same way for more than 70 years. To reduce the workload of clinicians and to shorten diagnostic time, computer systems were developed. By the early 1960s Pipberger et al. developed a computer algorithm which attempted to differentiate between normal and abnormal ECGs [162], [163]. As systems design and methodology developed, algorithms became commercially available in the early 1970s [164]–[166]. Computerised ECG analysis has progressively improved ever since with more computer systems becoming available and algorithms becoming more sophisticated [167].

2.2.2.3.1 The computerised diagnosis of the ECG

Typically an ECG is printed on graph paper and presented to an interpreter in a 3x4 grid format with each cell representing one of the 12 ECG leads [59]. This can also be accompanied by an extension of Lead II to help assess cardiac rhythm (3x4 + 1R). This presentation of ECG signals can deliver significant cognitive load [95], thereby contributing to the depletion of an interpreters' cognitive thinking ability. Therefore, to help alleviate this cognitive workload and to decrease diagnostic time, this format of ECG presentation is often supplemented by computer analysis, often presenting the interpreter with an automatically generated ECG interpretation and diagnosis.

Routinely, computerised ECG diagnostics is composed of four main steps; 1) Signal pre-processing, 2) QRS detection, 3) feature extraction and 4) signal classification

[168]. Computerised analysis of severe cardiac conditions such as Acute Myocardial Infarction and AV blocks are often inaccurate [65]. Many previous investigations into computerised ECG diagnostics corroborate and indicate the unreliability of computerised diagnoses, which can lead to both improper use of medical resources and adverse patient treatment planning [19], [74], [169], [170]. Therefore, computerised ECG interpretation should always be over-read by a clinician, especially in non-sinus rhythms [74]. Furthermore, since current computerised ECG interpretation often only provides a single diagnosis, it can contribute to a number of cognitive biases, (1) anchoring bias (fixation on a premature suggestion/answer/diagnosis/interpretation), (2) confirmation bias (seeking features/annotations to confirm rather than falsify a diagnosis) or (3) premature closure (acceptance of a diagnosis before verification) [18], [21]. Therefore, numerous studies have recommended computerised ECG interpretation should always be accompanied by clinical human affirmation [12], [171].

2.2.2.3.2 ECG interpretation accuracy; human vs. computer vs. both

Computer algorithms are often used as an adjunct to ECG interpretation. With an estimated 50 million ECG interpretations being annually conducted in the United States of America with the use of computer analysis. However, research has established how computerised ECG interpretation can have both a positive and a negative effect on an interpreter's clinical diagnosis.

Computer algorithm accuracy in ECG interpretation; It has been widely accepted that computers can make more accurate precise measurement of conventional ECG tracings than the human reader [19]. The best computer algorithms have been found to be almost as accurate as the best cardiologists in classifying an ECG in common diagnostic groups [172]. However, there is a vast range in correct classification of interpretations from various computer algorithms, with arrhythmias proving most problematic to diagnose [10]–[15]. Computer programs can also assist in achieving more uniform and consistent ECG interpretations [11], [19].

Numerous studies identify that although correct computer analysis increases diagnostic accuracy, incorrect computer analysis has a detrimental effect on the final interpretation accuracy of the interpreter [11], [18], [19]. Therefore, this illustrates an over reliance on computerised interpretation which, in turn, can lead to distrust in ECG computer analysis [11]. Brailer et al., among others, also noted using computer-assisted ECG interpretation with physicians can decrease interpretation time by up to 28% [6], [11], [15].

Human accuracy in ECG interpretation; human visual perception is superior to machines in pattern recognition ability [16], [17]. Berger et al. identified a median correct interpretation identification rate of 60% in a study on ECG interpretation in medical residents [91]. This score is further corroborated in other studies with a 36-80% correct identification rate [12], [88], [90], [173]–[177]. Qualified electrocardiographers can have an accuracy of around 80% [178]. However, diagnostic accuracy has been reported to be as low as 40% [92], [94], [179].
Nevertheless, Willems et al. noted when investigating the diagnostic accuracy of interpretations from both 'average' computer algorithms and 'average' cardiologists, the cardiologist was twice as likely to be correct when measured against clinical diagnostic criteria [172]. Willems also noted, most cardiologists performed better at normality diagnoses and had a higher sensitivity in diagnosing AMI. As previously stated, it is also recognised that clinical scenario and patient history can play a vital part in the cardiac assessment. In which case a computer algorithm cannot easily make an accurate assessment without this being incorporated within the system [90], [180]. Also, one study highlighted that senior house officers (SHOs) have a high error rate when interpreting ECGs than experienced consultants, and this error rate is not significantly reduced when a computerised interpretation aid is introduced [12].

Combining ECG interpretation methods; When both human interpretation and computer interpretation is used in combination studies almost exclusively recommend the best approach is one which combines both person and machine [6], [22]–[26]. Some reasoning is formed due to human cognitive memory prevailing in pattern recognition (i.e. in noisy signals) enabling the interpreter to provide more accurate annotations whilst a machine performs better at using annotations to reason against a large set of rules (ECG criteria). This approach also facilitates accountability in clinical decision making. Therefore, computerised ECG interpretation and analysis should always be considered a useful adjunct to the clinical decision making process, but not a substitution for a clinician's cognitive effort.

2.2.2.3.3 Other computerised decision aids in electrocardiology

Some abnormalities are not always clearly visible on the printed 12-lead ECG [181]. Therefore alternative methods of visualising ECG data have been developed [182]. This is highlighted in the range of visualisation methods that have been developed to present the ECG, and hence aid the interpretation of ECG signals.

These include:

- Temporal ECG presentations (conventional graph paper: 12-lead ECG, the 13th multiuse lead, panoramic presentation of the limb leads, the mirror image ECG and integral images of the ECG),
- Vectorial ECG presentations (the mean frontal electrical axis, the vectorcardiogram and the ST-injury vector),
- Spatial ECG presentations (Body Surface Potential Map (BSPM), the isopotential map, the isointegral map, the difference and departure map, non-invasive epicardial map and the ECG polar plot) and
- Interactive methods which allow the data to be explored rather than simply viewed [60], [182].

Of this range of methods, the 12-lead ECG has become the standard temporal presentation to assess the cardiac state of a patient since its inception [60].

2.2.2.3.3.1 Body surface potential map visualisation

The Body surface potential map (BSPM) has been around in some format since 1889 [183]. The BSPM utilises over 200 leads placed across entire torso of a subject [184] and provides a spatial visualisation of the ECG. It visualises electrical data from extensive regions of the body and improves diagnostic accuracy when compared to that of the 12-lead ECG [185]. However, the BSPM has not been adopted for routine practice and further research is still needed to validate its utility.

2.2.2.3.3.2 ST-Mapping / ST vector visualisation

ST mapping has been developed to improve the visual representation of ST-segment deviations, and hence is displayed in a format that is more readily interpretable when compared to the typical 12-lead ECG. An ST-map involves vector calculations which are then visualised to assist both cardiologists and non-cardiologists to detect AMI [186], [187].

Other ECG visualisation techniques have been developed including epicardial mapping [188] and orbital transformations to the 12-lead ECG [181] among others [95], [189]–[194]. However, both Kligfield et al. and Bond et al. described how despite significant developments in technology and various computerised ECG visualisation developments, they do not foresee the standard 12-lead ECG presentation being replaced or substantially changed [60], [171]. However as the digitisation of medical services manifests the opportunity to augment and supplement the 12-lead ECG becomes apparent [27].

2.2.2.3.3.2 Interactive computing and decision support systems to aid ECG interpretation

Literature includes a variety of interpretation tools to assist clinicians in the assessment of ECGs. Decision Support Systems (DSSs) have been developed to help manage the interpretation process on a mobile device. Meng Lin [192] created an application which delivers an ECG image to a mobile device which allows users to scale, translate and rotate the image. The heart rate is also displayed. To enable these features remotely the ECG data is stored on a web server. When requested the application obtains the relevant ECG data from this web server. The data is then displayed using cascading style sheets (CSS3) and the hypertext mark-up language (HTML5). Thus users have access to this information using the mobile ECG DSS from any web enabled smart phone [192]. This ability to digitally view an ECG from a patient at any moment in time provides a number of opportunities to create an interactive user interface to assist clinicians in their interpretation. For example, digitally viewing an ECG on a touch screen allows the user to pan and zoom to view abnormal waveforms in higher resolutions. This combined with a measurement tool can reduce the time and improve accuracy of the interpretation. Also if access is provided for raw data files, allowing access to the waveform directly, new opportunities begin to develop which could facilitate the ability to dynamically change the waveform into various supportive transformations, such as orbital transformation [181]. A study [192] also found that the acceptance of digitising the ECG is high with the majority of participants finding the waveforms being displayed better and that the data is more complete when compared to traditional thermal graph paper.

Tsai [18] conducted a study in which the aim was to ascertain the effect computer-based ECG interpretation has on the accuracy of a non-cardiologist . It was found that the DSS increases the diagnostic accuracy of medical students when interpreting ECGs. Despite this, incorrect computerised diagnoses significantly influenced their accuracy.

Similarly, Karlton Pettis conducted a study in which he evaluated the efficacy of hand-held computer screens for cardiologists interpreting the 12-lead ECG. His paper presents the results of a study between the conventional methods of ECG interpretation, from graph paper, compared with ECG interpretation from a digital display on a mobile platform. The main focus of Pettis's study was to compare the diagnostic accuracy of digital ECG interpretations when compared to the traditional method. To achieve this, twenty ECGs were chosen to conduct the study, each with clearly defined abnormalities. One group of participants was arranged and sent three sets of ECGs to interpret - two traditional paper based copies to act as the control groups (Pa & Pb) and one digital set using the ECGvu software, which were to be viewed in a Hewlett Packard Palm top (LCD). Information sheets were provided giving the participant a selection of answers to choose from. Responses were then written on an answer sheet and sent back to the ECG core lab. The ECGs were randomised between participant groups and one month was given between tests to allow for the same ECGs to be reused. When the two traditional paper based sets were compared, 89% of interpretations were indistinguishable. Between control group Pa and the experimental LCD group 88% of interpretations were identical. Similarly, between the control group Pb and LCD group 87.5% of ECG interpretations had the same results. These differences were statistically insignificant (P = .75 and P = .88, respectively) with the difference between intra-observer accuracy in the paper-paper test being 1% and paper-LCD being 1.5%. Only the ECG indicating Wolff-Parkinson-White syndrome received more accurate diagnoses in the control tests. The subtlety of the delta wave was thought to have caused this as on the small LCD screen it may have been difficult to distinguish. The results provide evidence that participants reach the same ECG interpretation regardless of the media it is displayed on. It must also be noted that at the time of this study only 40% of participants had previously diagnosed ECGs via a computational device. This could indicate results may improve with greater digital uptake in ECG interpretation and familiarity with the device in use. Common familiarity with digital devices ranging from mobile telephone to tablet computer has vastly improved since this study was undertaken and hence there are opportunities to re-evaluate the interpretation process on digital modalities [195].

As previously discussed, the state of the art in CDSSs in electrocardiography often focuses on the computerised diagnostic aids which automatically interpret an ECG. However, these aids are; 1) frequently incorrect for ECGs presenting arrhythmias, conduction disorders and pacemaker rhythms, among others 2) have wide variations in false-positive and false-negative result in the identification of STEMI, 3) systemic over-reading by a clinician is mandatory [196]. Increasingly however, the ECG is digitally assessed on mobile devices without bespoke computerised aids [197]. Nevertheless, this method of ECG analysis provides the interpreter with the ability to zoom. Enabling ECG artefacts and features to be explored and help determine the correct interpretation. Thus, unconsciously deconstructing the cognitive heavy workload a full 12-lead ECG requires. This method of ECG interpretation is becoming increasingly commonplace with end-to-end encrypted image transfer facilities become readily available in mobile devices. This has been verified in literature [197] and experienced first-hand through clinical practitioner communication and evidences the human remaining a continuously central figure in the interpretation process. However, security and accountably concerns still remain as part of this process.

2.2.2.4 The role of human-computer interaction in decision support systems

In a recent survey of informaticians, the biggest challenge facing clinical decision support is in improving the human–computer interface [158]. This is corroborated by Horsky et al. stating that developing effective CDSS in a complex and dynamic domain of clinical medicine is a major challenge for designers [198]. Horsky continues to elaborate by illustrating poor usability as being one of ‘core barriers’ to system adoption and has a detrimental effect on regular use. This is echoed by a usability task force set up to define and test Electronic Medical Records (EMR) which highlights "*The quality of CDSS design and human–computer interaction characteristics of its interfaces are among the most decisive factors determining the effect of CDSS on care and patient safety by influencing the adoption rate and routine use by clinicians*" [199], [200].

It is therefore apparent, and recommended, that CDSS incorporate clinicians within the design process from inception. This enables clinical requirements to be outlined and deliberately embodied with the system [20], [201]. Furthermore, a clinical aspect should also be considered and frequently evaluated throughout the development process to ensure essential clinical characteristics of the system are included or are augmented with improved ideas [20], [201]. Consequently, developing appropriate design strategies are a key component in creating a CDSS which meets the clinical requirements.

However, a well-defined, clinically accepted set of design standards has not been developed which applies to all CDSS and therefore most institutions use independent, proprietary guidelines which can vary greatly [202]. Horsky recommends development institutions "*need to adopt design practices that include user-centred, iterative design and common standards based on human–computer interaction (HCI) research methods rooted in ethnography and cognitive science*" [198]. To date, the largest set of design standards for CDSSs has been put together by Microsoft in cooperation with the NHS, and is known as the Common User Interface (CUI) [202]. The objective of the CUI is to "support the delivery of safe patient care by providing detailed guidance for the standardisation of clinical application user interfaces" [203] whist providing guidance and recommendations on clinical noting and terminology, consistent navigation, patient identification, patient medication display and interaction, and accessibility requirements [202]. Comparable initiatives have taken place in the United States of America (USA) in institutes such as National Institute for Standards and Technology (NIST), Agency for Health care Research and Quality (AHRQ), Health Information and Management Systems Society (HIMSS) [204]–[210]. However, a collaborative consensus has yet to be established.

2.2.2.4.1 Human-computer interaction in decision support in healthcare

To underline the importance of human-computer interaction principles within a hospital setting, one study illustrates how human factors accounted for 45% of reported problems. The factors which have been attributed to this percentage include relatively simplistic tasks such as; data entry (64%), retrieval of patient data and retrieval of clinical data [211]. Other studies illustrate how inadequate interface design can have a negative effect on clinician cognitive performance [212], [213] and require rework [211]. Deficient interface design may also threaten patient welfare by; requiring/causing unsafe workarounds [212], [213], facilitating medication errors [212], [213] and exacerbate substandard response rates to safety prompts, alerts or warnings [214].

Despite these concerns, decades of research have illustrated significant improvements in safety can be achieved throughout various interdisciplinary domains ranging from the nuclear power to medicine by applying standardised human factors design methods, HCI principles and defined user experience guidelines [215]–[218]. Following the publication of the Institute of Medicine report, to Err Is Human, HCI in CDSS has become an essential component of the desire to improve patient safety [219].

2.2.2.4.2 Recommendations for human-computer interaction in CDSS

Horsky et al. states the aim of HCI recommendations are to "*...shorten the time required to gain interaction proficiency, and lower cognitive effort and mental fatigue" placed upon a user* [200]. This is corroborated by various other commentators [200], [220]–[223], salient points of which are described below.

2.2.2.4.2.1 Consistency

A consistent user interface design permits efficient perceptual judgements [144], [224]. Therefore, predictable colour coding, uniform visual hierarchies, homogenous wording style and consistent navigational controls should be employed across all interconnected systems [105], [225]–[227]. Consequently, actionable interactive options should stand out as visual cues within a system interface [222]. In contrast inconsistent design encourages strenuous, cognitively demanding and error-prone task completion [198].

2.2.2.4.2.1 Workflow integration

A clinician's time is valuable. To complete a task, clinicians have to make swift decisions based on evidence or advice and determine an appropriate course of action. Therefore, it is vital CDSSs integrate seamlessly within this process [220] and present salient recommendations at the point of care [228], [229]. Although human visual perception fixation time is under half a second (230ms) [230]–[232], Hick's law states that decision time is logarithmically proportional to the number of choices presented [233]–[235].

The difficulty in task completion is often misunderstood as number of actions (button clicks) required to complete a task, as clarified by Nielsen [236] and Porter [237]. However, application speed and an appropriate visual hierarchical structure are a much better examples of hindering task completion [238], [239]. As system speed needs to reflect efficient clinician performance, CDSSs should employ effective methods of enhancing performance. Recommendations have been made to manage information density by employing suitable visual hierarchical structures, and to anticipate potential user action sequences [222]. One such method, which attempts to accomplish this, is Fitt's Law. Fitt's law reveals "…the time to acquire a target is a function of the distance to and size of the target", therefore, CDSS designers should enlarge and increase proximity to targets when anticipating user actions [238], [239].

2.2.2.4.2.1 Developing and nurturing trust

For clinicians to be accurate in diagnosis, efficient, and not endanger patient safety a CDSS must garner trust while in use. Although interactivity, visual hierarchy and cognitive workload all influence clinician perception of a CDSS, Horsky et al. states "*High specificity and relevance of alerts is crucial for developing confidence in the ability of the system to make accurate suggestions"* [200], [240] whist and Ahearn et al. corroborates this sentiment. Thus, developers of CDSSs should refrain from creating a 'black box' application which cannot accommodate clinician critical evaluation of a proposal [200], [220], [241]. However, it must also be noted, the presentation of extraneous data may also lead to an inversely proportional effect of the success of a CDSS [220], [242].

2.2.2.4.2.1 Suggest - not inform

A CDSS knowledge base often stores expert knowledge distilled by a domain specialist [137]. However, due to computer-generated diagnoses often 'stating' a proposal, rather than offering a suggestion, a clinician may perceive CDSSs impair professional autonomy in a domain in which they consider themselves to be experts [243]. As a consequence, CDSSs should refrain from informing a clinician with diagnoses, instead offering potential proposals of recommended actions [244]. In the same way, a CDSS needs to garner trust in its ability to perform, suggested courses of action should always show clarity in a decision allowing clinical experts to critically evaluate the proposal. And hence, as stating a proposal is not an effective method for changing practice [155], [245], proposals should also contain at least one recommended action. It has been recommend that the infinitive sentence construction should also be used to prompt a reader as it has been proven to prevent errors associated with reader reactions [246].

2.2.2.4.2.1 Human interaction assessment

To understand if a CDSSs features (prompts, suggestions, alerts or warning) are being utilised to potential capacity it is important to periodically review system logs. If a particular feature is under represented, a consideration may need to be made to alter the design, position or hierarchical level [198].

2.2.2.4.2.1 Maintenance and legacy CDSS systems

A CDSS should be able to operate even if data becomes obsolete, is missing or when individual components fail. This concept is known as "graceful degradation" [215].

Although time consuming and often costly, CDSS knowledge-bases should be regularly updated with up-to-date peer reviewed research to enhance operation capabilities and thus benefit patient wellbeing [158], [159]. However, a CDSS should provide the ability for development institutions to flag when/if diagnostic criteria are under review or become obsolete. These flags should appear as warnings/alerts to clinicians to take under consideration.

2.2.2.4.2.1 Erroneous data entry prevention

There is also a need for clinicians to use concise and unambiguous language whist maintaining consistency in terminology [198]. Considerately designed CDSS can help achieve this objective through concise, consistent, hierarchical visual displays which encourage accurate freehand data entry [158], [220], [222], [247]. Alternative methods of attaining accurate data entry include a reduction in freehand data entry and a migration towards case specific option-bases. These option bases allow users to select predefined options from checkboxes, radio buttons, or statements from dropdown menus. Thus, they encourage/force consistent terminology and reduce potential variability in diagnoses [215]. Finally, on completion of a task, a review of clinician decisions should take place to ensure erroneous data is detected and amended [160].

2.2.2.5 Continuing development of CDSSs

Henceforth, CDSSs should seamlessly augment clinician decision making at the point of care. A CDSS should act unobtrusively suggesting courses of action and recommend potential diagnoses without instructing a clinician. Successful CDSS should also accumulate trust in its ability and reduce a clinicians cognitive effort and potential mental fatigue. Furthermore, following recommended standards and approaches to HCI in healthcare, CDSSs should facilitate dynamic interface reorganisation providing relevant user action sequences when a clinician’s requirements are predicted. If these features can be addressed, specifically the reduction of the cognitive workload and trust procurement, CDSSs will augment the human decision making process.

A CDSS is recognised as an augmentation tool to assist the clinical choices made by a clinician. To achieve this, a CDSS typically provides a suggestion(s) for a clinician, of which the clinician uses their clinical judgement to interpret these results, select pertinent information and discount erroneous suggestions [20]. With this in mind, the following chapters describe the knowledge-based decision support system which uses interpreter annotations and recognised diagnostic criteria to augment the human interpretation process. A knowledge-based approach was chosen to utilise the provision of both human annotations generated through system use and recognised diagnostic criteria garnered from literature, clinicians and acedemics.

2.3. Conclusion

In this chapter, some of the complex concepts which govern the field of electrocardiology are discussed. By illustrating the cardiac circulatory system and the electrical conduction system of the heart we can easily determine the nature of cardiac assessment is indeed a complicated endeavour.

Many novel methods of cardiac assessment have been developed to help clinicians with this task, with electrocardiology often central in venture. However, as identified, electrocardiology has its limitations. To help alleviate these limitations clinical decision support systems have been developed to augment human interpretation of the electrocardiogram. Nevertheless, these are often also impeded by diagnostic accuracy concerns and inability to involve the clinician in the decision making process.

Therefore, over the course of the following chapters, the research aim is to further augment the human interpretation of the 12-lead ECG by using human-computer interaction principles to incorporate the clinician into the decision making process. We hypothesise this may create an optimal man-machine model to promote human interpretation whilst utilising the processing capabilities of a personal computer.

Chapter 3:
An Interactive Progressive-based Model to Aid the Human Interpretation of the 12-lead Electrocardiogram

3.1 Introduction

As previously identified in Chapter 2, digital diagnostic tools are used to help a clinician diagnose and treat medical conditions such as cardiovascular disease. With the prevalence of CVD, causing an estimated 17.5 million deaths each year [1], it is therefore imperative to optimise the clinical decision making process using clinical decision support tools (or CDSS).

Although the 12-lead ECG is an important diagnostic support tool in the detection of cardiac abnormalities, a number of concerns have been raised, including;

1) Inaccurate interpretations: It has been reported that up to 33% of ECG interpretations contain errors of major importance [91]. Routinely cardiologists correctly identify between 53% to 96% of the abnormalities depending on the abnormality present. However, the correct identification rate for non-cardiologist interpretation falls to between 36% to 96% [61], [93].
2) Variable interpretation agreement: Furthermore, there is a moderate degree of interpretation variability between cardiologists as there is not always agreement in interpretations of the same ECG [6], [8].
3) Demanding cognitive performance: As we know, a typical 12-lead ECG comprises of many recordings from various electrode sites placed on the human body. This accumulation of information delivers a significant cognitive load for the interpreter which in turn can have a detrimental effect on the cognitive thinking process [95]. A human working memory has a predetermined capacity [95], [248], [249], and the ECG assimilates a large number of variables comprising of 12 signals and a rhythm strip, each having multiple complexes and deflections as well as computerised metrics (e.g. automatic interval and segment measurements). As a result, it is obvious that the human cognitive ability will deplete rapidly during ECG interpretation [95]. In addition, ECG interpretation is also challenging since it warrants the need for interpreters to make associations between various signals and the mechanical health of the heart (often referred to as the electromechanical link). Given the difficult-to-remember subject matter, it is a typical expectation that students, teachers and even experienced clinicians find the ECG difficult to interpret [4].

4) Elicits hasty reactions: ECG interpretation is complex and is often challenging for an interpreter, an eye tracking experiment identified that even expert ECG clinicians can misdiagnose and miss co-abnormalities. Experts suffer from 'early satisfaction syndrome' when looking at all 12-leads in a single presentation. For example, they rapidly identify one abnormality and diagnose the subject without giving appropriate consideration to the remaining ECG tracings [8], [9]. Hence, they provide a conclusion prematurely as they are 'satisfied' that they have identified all abnormalities. During this study, experts also missed obvious lead misplacement features and visually ignored a number of leads.

To combat these concerns, ECG reporting can be used in conjunction with checklists. Such checklists do vary regarding their content and sequence of 'checks' depending on the institution, however they generally follow a common sequence [4], [17], [37], [69], [70], [72], [250]. The typical sequence involves: 1) heart rate, 2) rhythm analysis, 3) cardiac axis, 4) conduction times, 5) morphological features, and 6) final diagnoses.

Therefore, an interactive computing model has been hypothesised (with built-in prompts), which exploit the functionality of modern mobile touch screen devices may reduce ECG interpretation errors as it would guide the ECG interpretation process. The model would deconstruct the process into a series of sub-tasks, which are completed with prompts and decision support. This deconstruction would also elicit a more manageable cognitive load on the clinician by allowing them to focus on specific leads matched by specific questions and prompts. Thus, the clinician's cognitive load is reduced due to the restructuring of a large aggregation of data. Furthermore, by limiting what an interpreter views during each stage of the sequence, the temptation for experts to jump to diagnostic conclusions is minimised.

Such a model can now become a reality given the prevalence of interactive touch screen devices and tablet PCs. This is also accelerated by the objectives of national health institutions such as the National Health Service (NHS) in the United Kingdom (UK) whose aim is to digitise healthcare processes [27]. By digitising the ECG and guiding the interpretation process we can exploit the aforementioned human-computer interaction principles (Chapter 2, section 2.2.2.4.1) and new/emerging technologies to improve diagnostic accuracy.

3.2 Model design

A literature review was undertaken regarding approaches for designing healthcare software interfaces [160], [251] and cognitive engineering methods enabling the reduction of cognitive workload [248], [249], [252]–[255]. Observations and guidance from both expert clinicians and teaching professionals in electrocardiology was then given, adjustments made, and a new interpretation process was designed.

A model for interactive ECG interpretation was developed within this PhD. The model comprised of a set of interactive questions and prompts which would direct an interpreter through a series of ECG reporting components. This set of questions and prompts were designed to reduce the cognitive workload forced upon the interpreter by segmenting the 12-lead ECG into the five central components of a typical ECG reporting procedure, often defined as a checklist by some institutions. The checklist of questions and prompts included within this model result from institutional guidelines on the ECG interpretation process, with some recommended clinical and academic alterations to ensure the model would be appropriate for a digital system. This five-step procedure is then presented over five web-based graphical user interfaces as seen in Table 3.1 and Figure 3.2.

Table 3.1. Segment presentation of the 'Interactive Progressive based Interpretation' model comprising of a brief description of the segments prompt and purpose

Segment no.	Leads presented	Description
1	Rhythm strip	This user interface presents an ECG rhythm strip with the prompt: "Interpret the rhythm strip". The purpose of this page is to facilitate heart rate and rhythm analysis.
2	Lead II P-wave	This user interface presents lead II with the prompt: "Interpret the P wave morphology". This segment facilitates the P-wave interpretation of the ECG. The P-waves of an ECG represents the atrial depolarisation. This interface is used to assess the morphology of the P-wave and the PR interval.
3	Limb leads	This user interface presents the limb leads, with the prompt: "Interpret the limb leads". The interpreter is requested to assess the cardiac axis, the ST-segment, the Q wave and the T wave.
4	Chest leads and Rhythm strip	The precordial leads are presented in this user interface with the prompt: "Interpret the QRS morphology". Again, this section requests conduction times and morphology assessment. A QRS assessment is required alongside a measurement of the QT interval duration. However, due to the variance of the QT interval depending on the heart rate this measurement needs to be corrected. This can be achieved using Bazett's formula: QTc = QT interval / ($\sqrt{}$ R-R interval) [37], [78]. Following the measurement and input of values for the QT interval and the R-R interval the QTc is automatically calculated by the IPI system and presented as shown in Figure 3.1. The cardiac axis, the ST-segment and the Q and T waves also require interpretation. An image of the rhythm strip accompanies the precordial leads to aid the assessment of the R-R interval.
5	All 12-leads	This user interface shows the complete 12-lead ECG – It requires the interpreter to assess R wave progression and lead misplacement. Finally, this section requires a conclusive interpretation to be provided for the ECG.

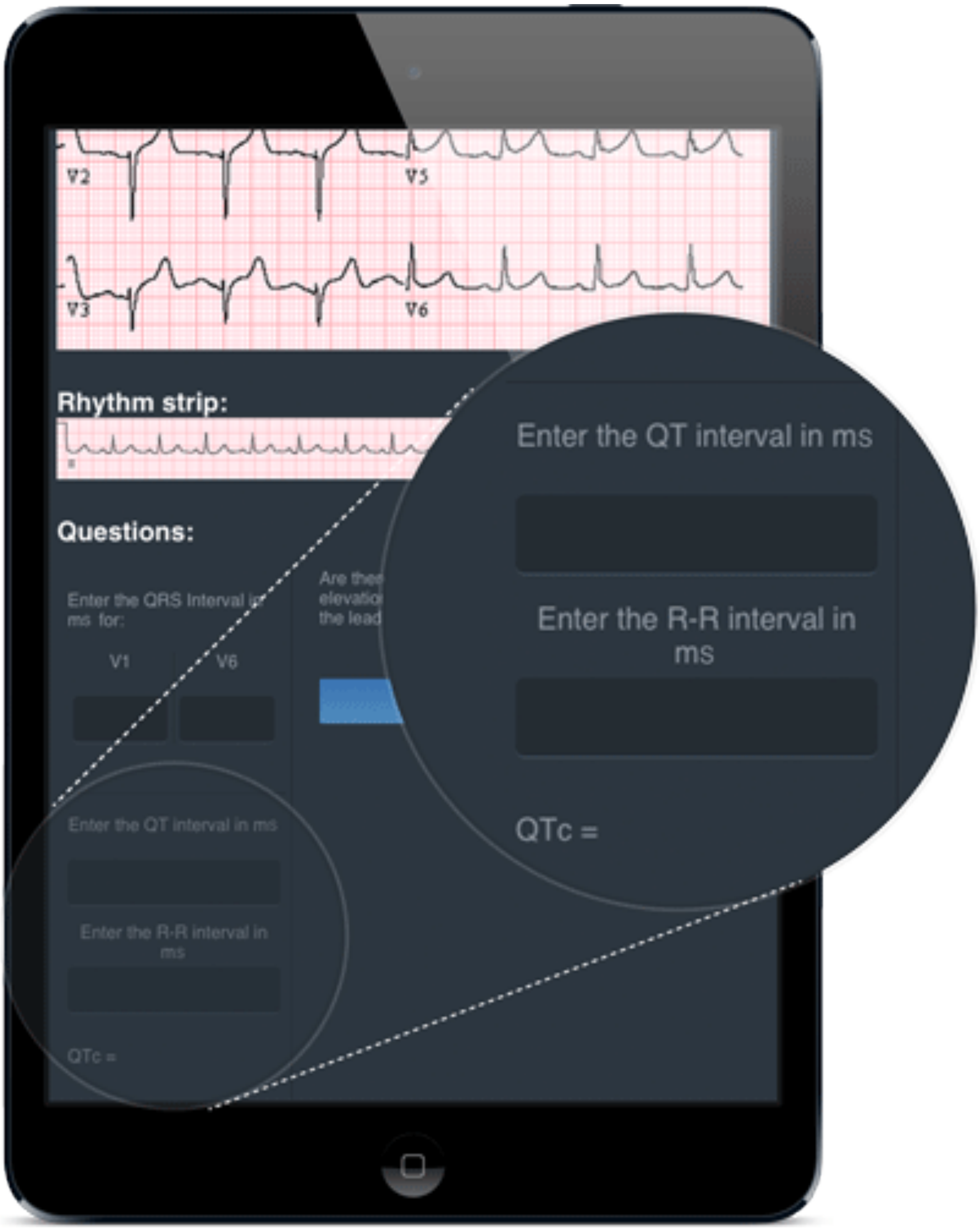

Figure 3.1. QTc calculation on segment four of the IPI system. When an interpreter enters the QT interval and the R-R interval in milliseconds the IPI system automatically calculates the QTc.

This model was named ‘Interactive Progressive based Interpretation’ (IPI). Additionally, by presenting the process for ECG interpretation across five web based user interfaces, we hypothesised that this would reduce the temptation for interpreters to overlook clinical information and provide a ‘knee-jerk’ reaction by providing rapid decisions (such decisions are often focussed on a single-abnormality). Thus, by segmenting the ECG in this way we can deconstruct a complicated task into a series of sub-tasks with prompts and decision support. This deconstruction would in turn also elicit a more manageable cognitive workload on the clinician. This deconstruction of large tasks into more manageable sub-tasks aligns with psychology research which aims to reduce cognitive load in multimedia learning [248].

It should also be noted that following a checklist does not increase the cognitive workload forced upon an interpreter, and yet does benefit the clinical decision making process. By using the dual process theory of cognition (utilising both intuition and analytic thinking [also known as system 1 and system 2 thinking]) through following a sequential reporting procedure, succeeded by verification, diagnostic error can be reduced [95]. Therefore, by forcing an interpreter to analyse specific parts of an ECG in a sequence, reminiscent of a checklist, followed by a verification procedure (full 12-lead ECG presented in the final segment) the clinical decision making process should be enhanced.

Following research in this field and discussions with domain experts a prototype was created to form the structure of the five-step sequences. This prototype was create using Microsoft PowerPoint and incorporated prompts and questions for interpreters to take under consideration. Once the sequential process was finalised, the user interface was iteratively developed with feedback coming from both academic and clinical sources. To accomplish this, the IPI system was developed in accordance with human-computer interaction theory developed in Jakob Nielsen’s ‘10 Usability Heuristics for User Interface Design’ [221] and Ben Shneiderman's ‘Eight Golden Rules of Interface Design’ [256]. One key concept of a successful system found in both sets of guidelines is consistency throughout an application. This uniformity was implemented across each of the five webpages. This enables fast system adoption from a user and therefore allows interpreters to engage fully, without caution resulting from unpredictable system responses. Therefore, throughout the application all buttons, images, colour schemes and call-to-actions remain consistent and constant.

Another key concept in user interface design is user feedback. Making the user 'feel' part of the process. To accomplish this, system feedback was provided to interpreters on-screen and in real-time providing interpreters with the perception that they are directly involved in the interpretation process and do not have any experience of uncertainty or ambiguity caused by the system. This is visible throughout the application on sliding events initialized by a button press or text input. This is also seen in validation methods which are actioned when an interpreter enters and erroneous value. Flexibility is vital to a web applications operation. By utilising the provision of responsive web technology, the application can dynamically scale to suit any screen size. Therefore, enabling engagement from interpreters using various platforms and devices. Other principles were also considered throughout the design process including efficiency of use, visibility of system status, i.e. where the interpreter is in the interpretation process (step 2/5), similarities between system and the real world, i.e. the system uses language coherent with both cardiologists and non-cardiologists, error handling, and easy reversal of actions. The IPI model can be seen in the form of a flow diagram in Figure 3.2.

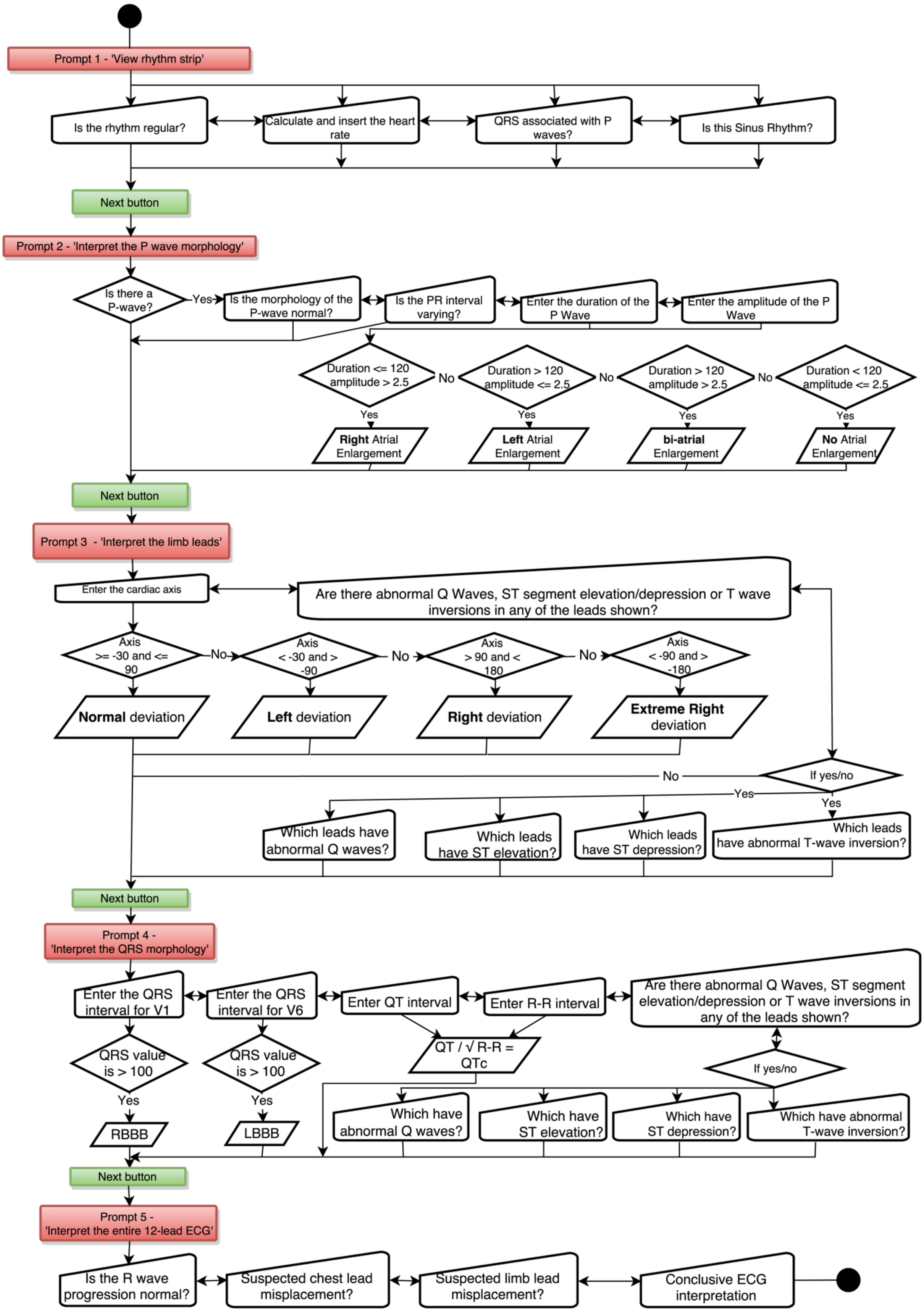
Prompt 1 - 'View rhythm strip'
Is the rhythm regular?
Calculate and insert the heart rate
QRS associated with P waves?
Is this Sinus Rhythm?
Next button
Prompt 2 - 'Interpret the P wave morphology'
Is there a P-wave?
Yes
Is the morphology of the P-wave normal?
Is the PR interval varying?
Enter the duration of the P Wave
Enter the amplitude of the P Wave
Duration <= 120 amplitude > 2.5
No
Duration > 120 amplitude <= 2.5
No
Duration > 120 amplitude > 2.5
No
Duration < 120 amplitude <= 2.5
Yes
Right Atrial Enlargement
Left Atrial Enlargement
bi-atrial Enlargement
No Atrial Enlargement
Next button
Prompt 3 - 'Interpret the limb leads'
Enter the cardiac axis
Are there abnormal Q Waves, ST segment elevation/depression or T wave inversions in any of the leads shown?
Axis >= -30 and <= 90
No
Axis < -30 and > -90
No
Axis > 90 and < 180
No
Axis < -90 and > -180
Normal deviation
Left deviation
Right deviation
Extreme Right deviation
No
If yes/no
Yes
Which leads have abnormal Q waves?
Which leads have ST elevation?
Which leads have ST depression?
Which leads have abnormal T-wave inversion?
Next button
Prompt 4 - 'Interpret the QRS morphology'
Enter the QRS interval for V1
Enter the QRS interval for V6
Enter QT interval
Enter R-R interval
Are there abnormal Q Waves, ST segment elevation/depression or T wave inversions in any of the leads shown?
QRS value is > 100
QRS value is > 100
QT / √ R-R = QTc
If yes/no
Yes
RBBB
LBBB
Which have abnormal Q waves?
Which have ST elevation?
Which have ST depression?
Which have abnormal T-wave inversion?
Next button
Prompt 5 - 'Interpret the entire 12-lead ECG'
Is the R wave progression normal?
Suspected chest lead misplacement?
Suspected limb lead misplacement?
Conclusive ECG interpretation

Figure 3.2. IPI system model illustrating the five step sequential process; 1) Interpret the rhythm strip, 2) interpret the P-wave morphology, 3) interpret the limb leads, 4) interpret the QRS morphology, 5) review the full 12-lead ECG.

3.3 Model implementation

For the model to be used 'ubiquitously' and without restraint, it was implemented as a platform independent and device agnostic system. To achieve this capacity, the system was developed using emerging web technologies such as the Hypertext Mark-up Language version 5 (HTML5) [257]. The HTML5 mark-up was designed to allow a web browser to render the webpage on any device. This is referred to as 'responsive design' where the user interface automatically adapts to the resolution of the device whilst the layout of the interface also optimizes to the user's screen size. Cascading Style Sheets version 3 (CSS3) [258] was also used to deliver a user experience with modern user interface aesthetics. The JavaScript scripting language [259] along with the JQuery framework [260] was used to provide user interactivity and responsive animations based on user input. All data is collected using interactive drop down menus, button selections and text field entry. The Hypertext Pre-processing language (PHP) [261] was used for parsing and saving user input values. All quantitative data collected from the study was saved and stored securely on an Apache web server [262] using a MySQL database [263]. User input data is seamlessly transferred to the server and saved after the user completes each ECG. This is done using Asynchronous JavaScript and XML (AJAX) [264]. AJAX is used to send data values to the server after each interpreted ECG as it avoids data loss in the event of all interpretations not being completed for any practical or technical reason as seen in a data flow diagram (DFD) [265], in Figure 3.3. The series of Structured Language Queries (SQL) [266] applied to the IPI system can be seen in Appendix A, along with the relative relational algebra [267], [268] and brief SQL description. Source code can be seen in Appendix B. Figure 3.4 is a presentation of each segment of the IPI system in use. Figures 3.5-3.9 illustrates each screen of the IPI model, whilst Figure 3.10 illustrates the view for the control group not using the IPI system.

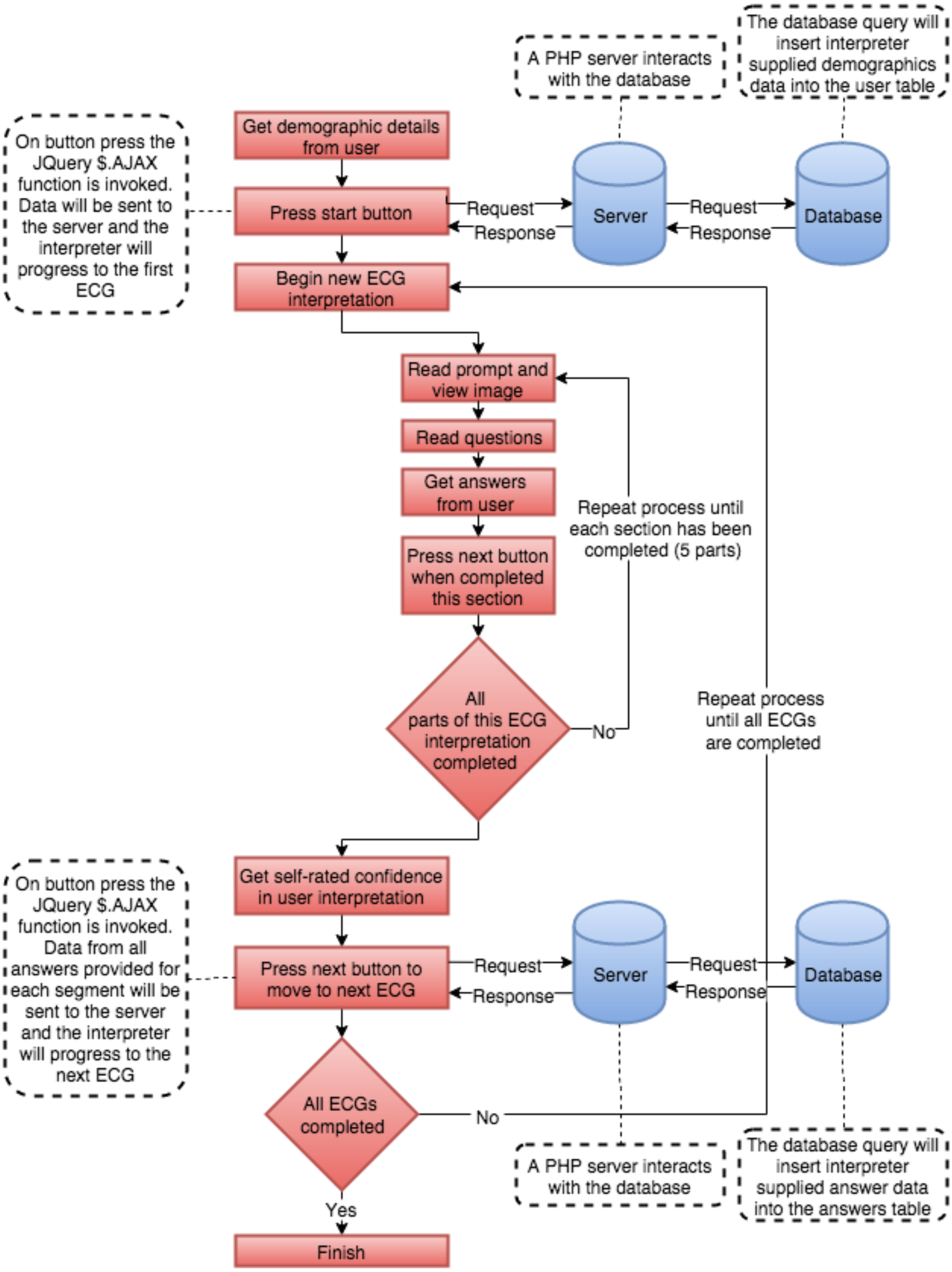

Figure 3.3. (Red = system protocol, Blue = user data movement, Dashed line = annotations describing the process). System protocol and data flow diagram illustrating when and how data is sent to the database.

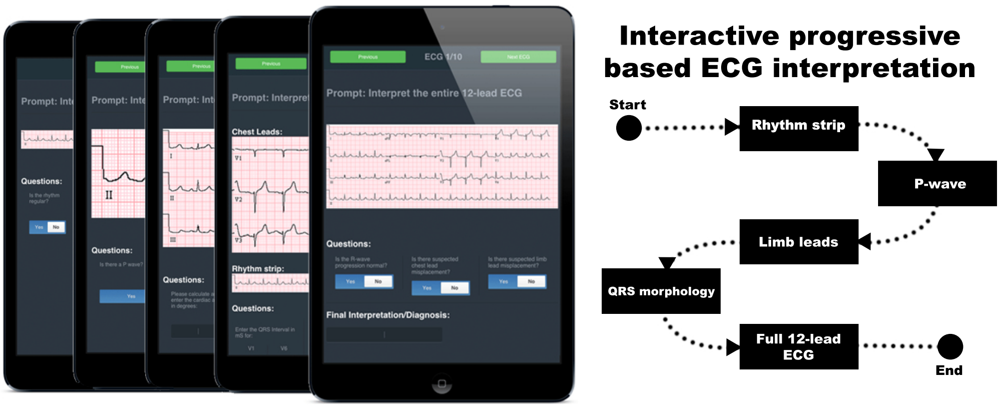

Figure 3.4. Presentation of each segment of IPI system;

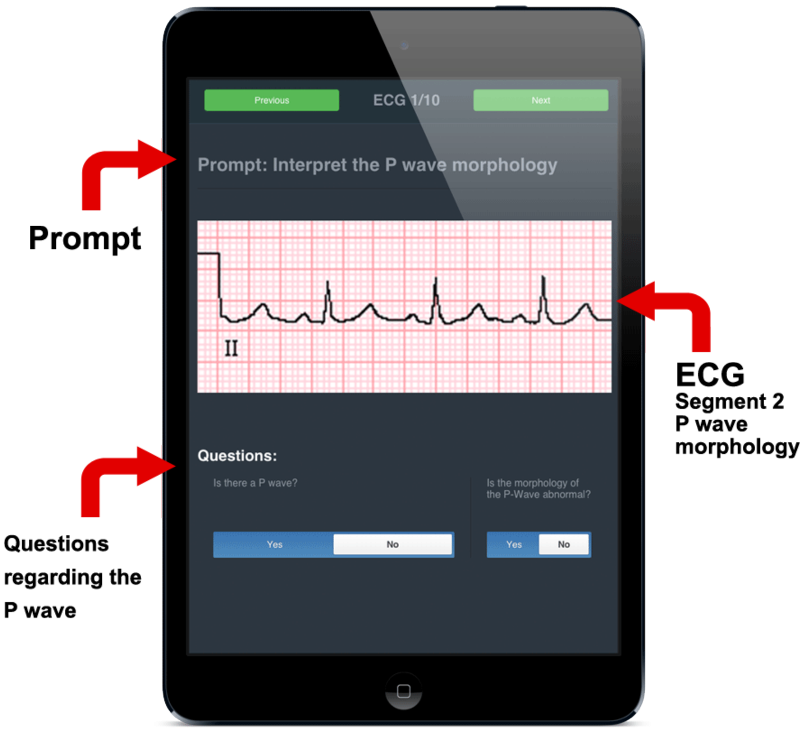

Figure 3.5. IPI model screen 1: Interpretation of the rhythm strip

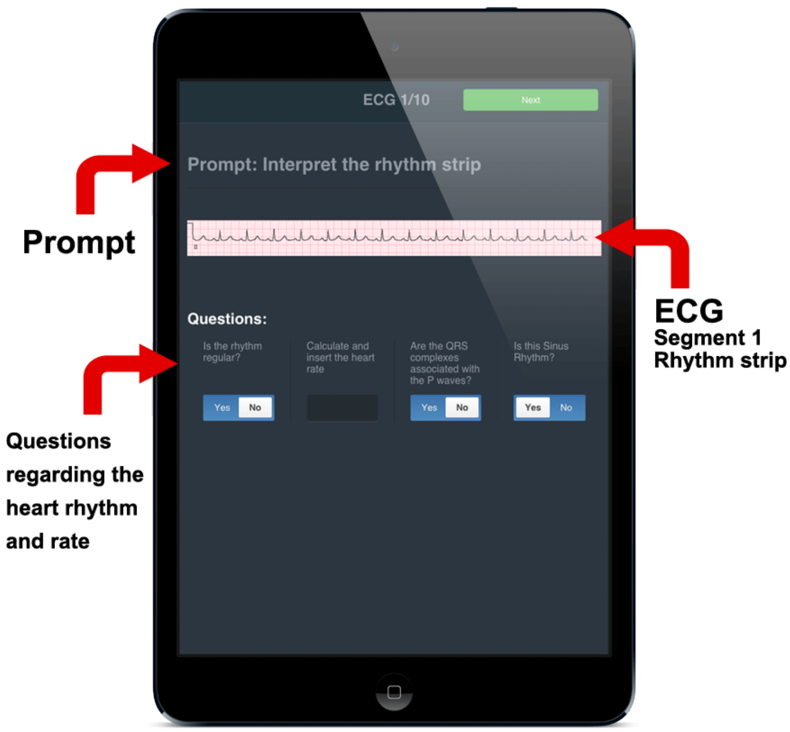

Figure 3.6. IPI model screen 2: Interpretation of the P-wave morphology

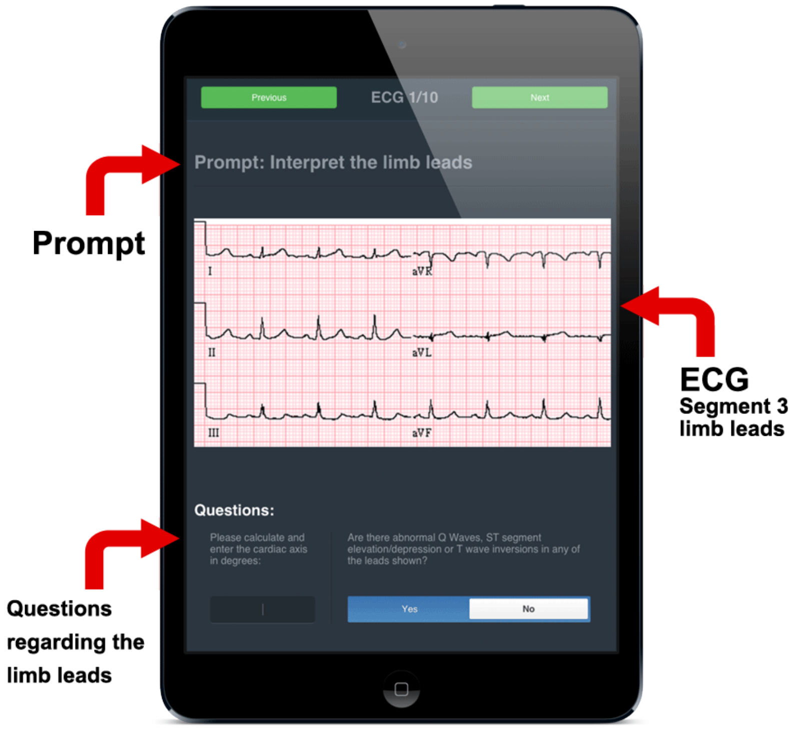

Figure 3.7. IPI model screen 3: Interpretation of the limb leads

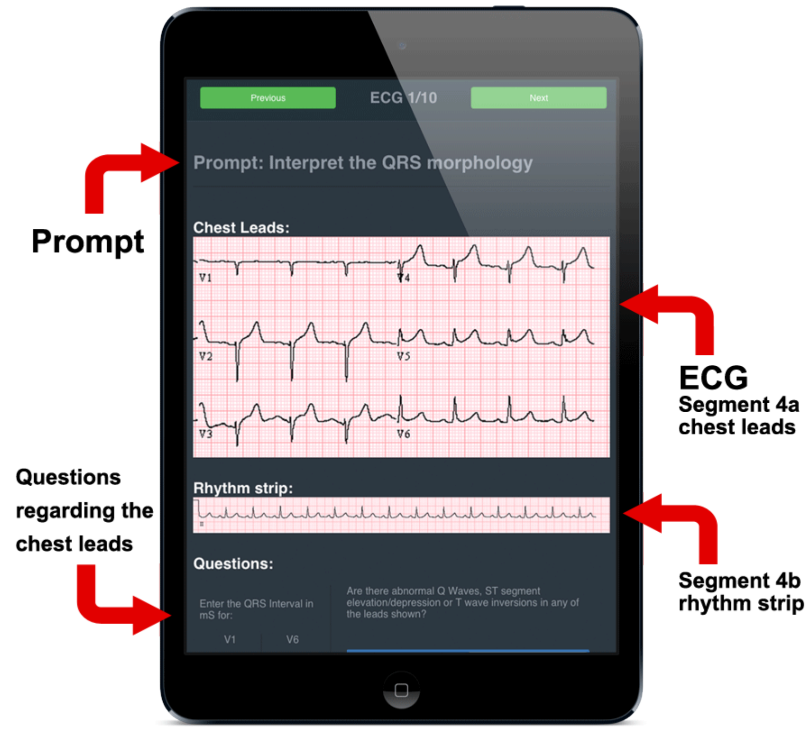

Figure 3.8. IPI model 4: Interpretation of the QRS morphology

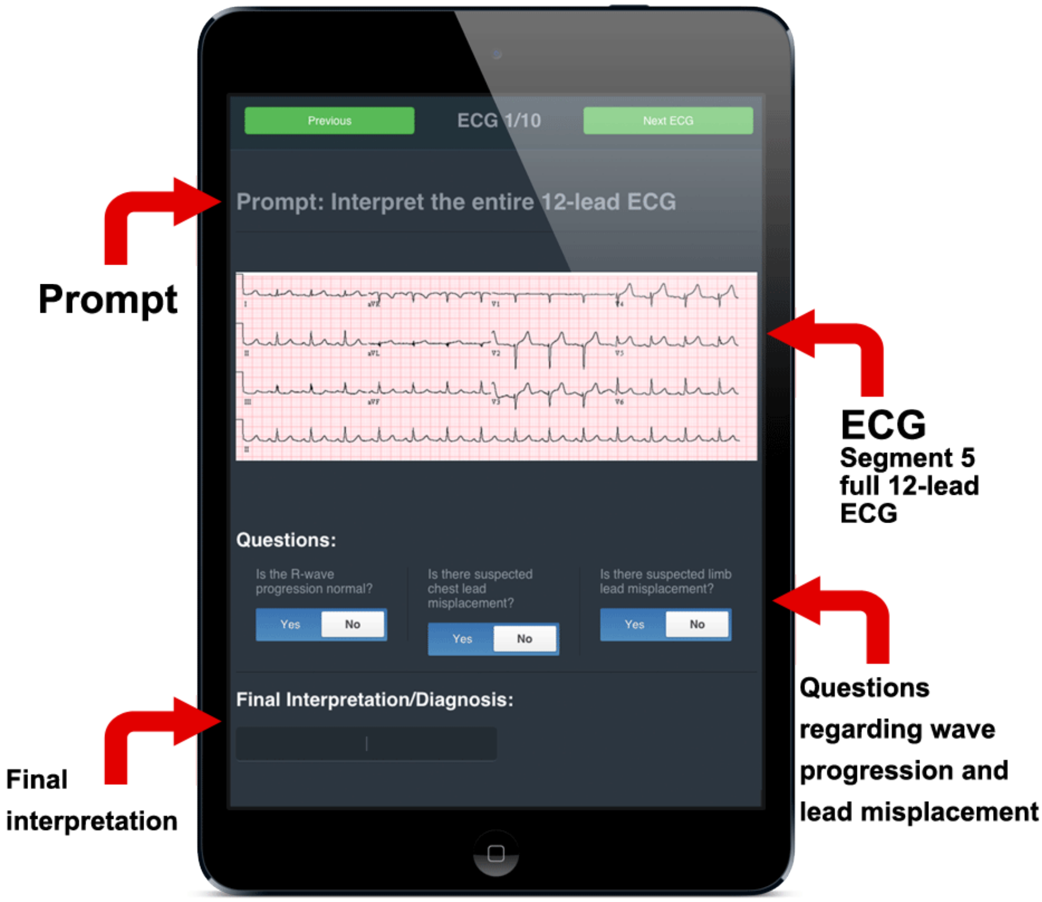

Figure 3.9. IPI model screen 5: Review the full 12-lead ECG

Figure 3.10. Presentation of the digital ECG interpretation method used for the control cohort. Interpreters were presented with an image of an ECG, given the prompt 'Review the entire 12-lead ECG', and asked to provide an interpretation of the full 12-lead ECG.

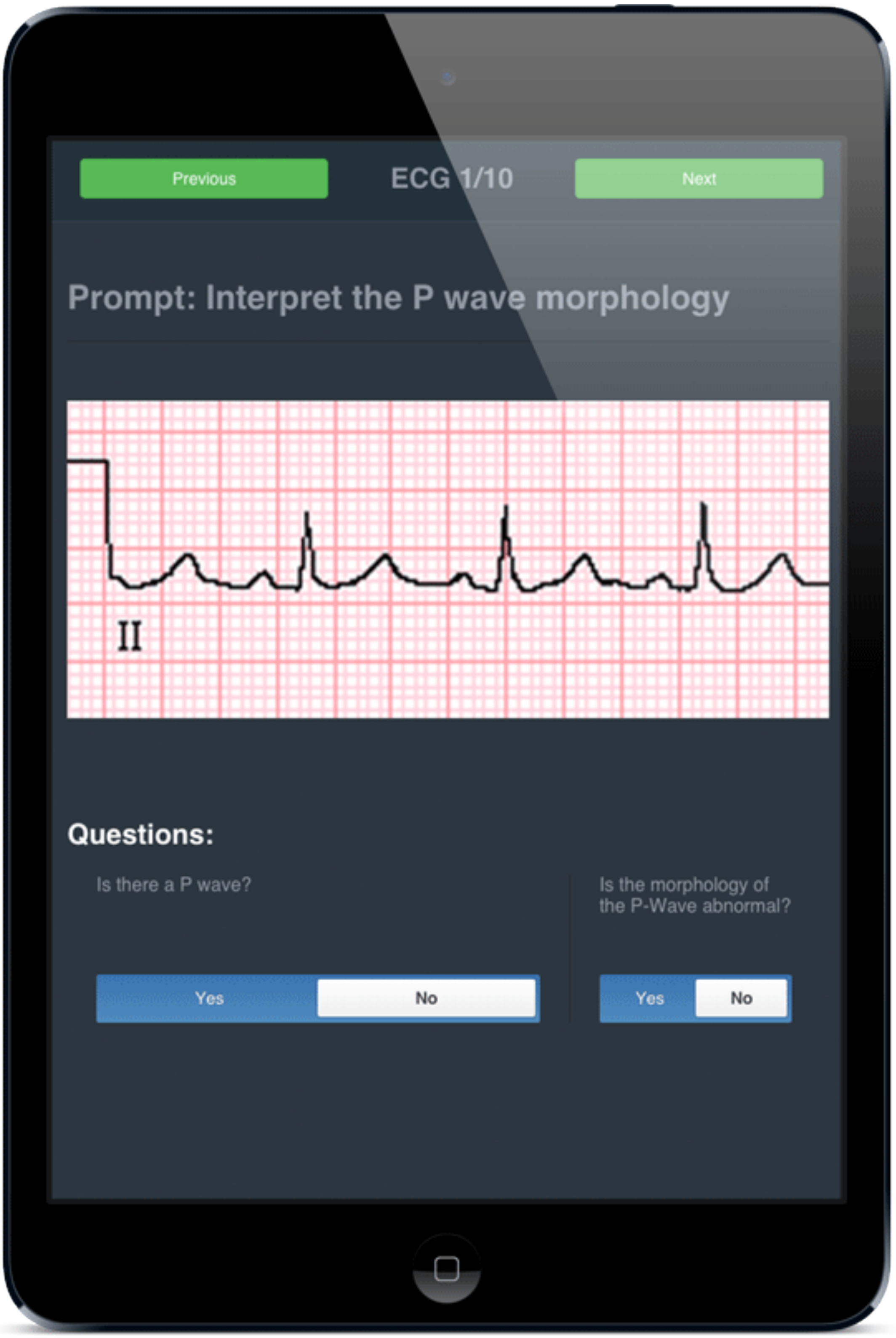

Figure 3.11. High fidelity image of segment 2 in the IPI model implementation illustrating the prompts, questions and ECG display

3.4 Conclusion

The potential to reduce ECG interpretation errors could be partly achieved using the proposed ‘clinician-friendly’ (features clarifying this statement are documented as part of the model design) interactive touch screen system to assist the interpreter in their decision-making processes. Hence, this chapter presents a novel model to augment the 12-lead ECG interpretation process where interpreters are systematically guided to sequentially interpret the 12-lead ECG as a series of sub-tasks. Therefore, we have hypothesised that this will reduce information overload and the cognitive workload forced upon the interpreter, and thus reduce the number of interpretation errors whilst increasing diagnostic accuracy. This hypothesis forms the basis of Chapter 4 which includes an evaluation of this model.

Chapter 4:
Evaluation of the Proposed Interactive Progressive-based Model for Interpretation of the 12-lead Electrocardiogram

4.1 Introduction

As alluded to in Chapters 2 and 3, typical 12-lead ECG interpretation often leads to inaccurate interpretations [61], [91], [93], variable interpretation agreement [6], [8], a demanding cognitive workload [4], [95], [248], [249] and elicits hasty reactions from an interpreter [8], [9]. Chapter 3 highlights a proposed interactive progressive-based model to augment the 12-lead ECG interpretation process. We anticipate that this computing model may reduce ECG interpretation errors as it would guide the ECG interpretation process and thus; increase diagnostic accuracy, reduce cognitive load and remove hasty interpretations errors. To evaluate this model, a study was conducted to measure its effect on the human interpretation of 12-lead ECG.

4.2 Methodology

A cross sectional study (refer to Figure 4.1) was carried out where a control cohort interpreted ECGs using the standard approach and an experimental group (IPI cohort) interpreted the same ECGs using the model described in Chapter 3. After subjects from both cohorts completed an interpretation, they were asked to rate their confidence in their decision from a scale of 1-10 (where 10 = very confident). Whilst subjects were randomly assigned to a cohort, the recruitment strategy was based on convenience sampling (suitable and available candidates from a cross section of occupations).

An overview of the study protocol has been outlined in Figure 4.2. In step one, interpreters were briefed with study information and guidelines. In step two interpreters navigated to system the Uniform Resource Locator (URL) via a pre-programmed link on either Personal Computers (PC) or provided tablet PCs. Using the system, the interpreters were then asked to provide demographic data in step three. In step four interpreters began interpretation of the first segment of the first ECG and iterated through the remaining four segments. In step five interpreters were asked to provide a self-rated confidence level of their final ECG interpretation. Step six, interpreters iterated through remaining ECGs (nine) while repeating steps four and five. Finally, step seven, having completed all interpretations interpreters navigated away from the system or returned tablet PCs.

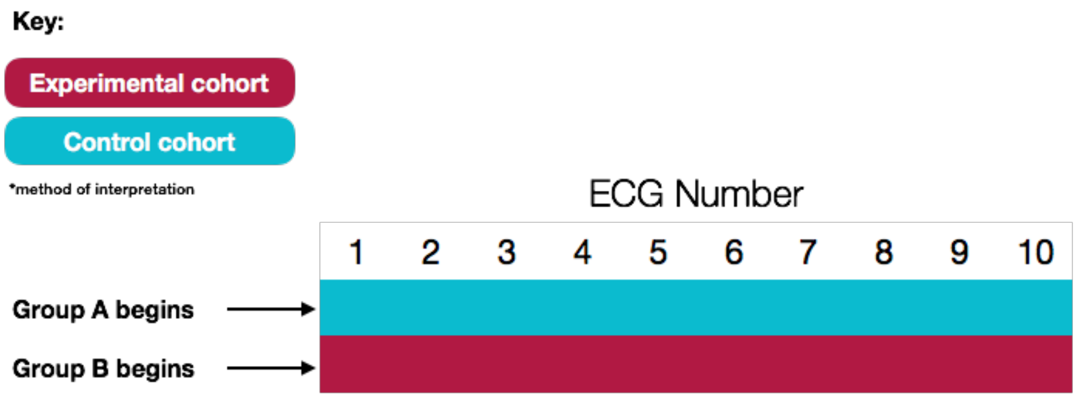

Figure 4.1. Cross sectional model for interpreters using both the experimental cohort using the IPI method of interpretation and the control cohort using the conventional method of interpretation

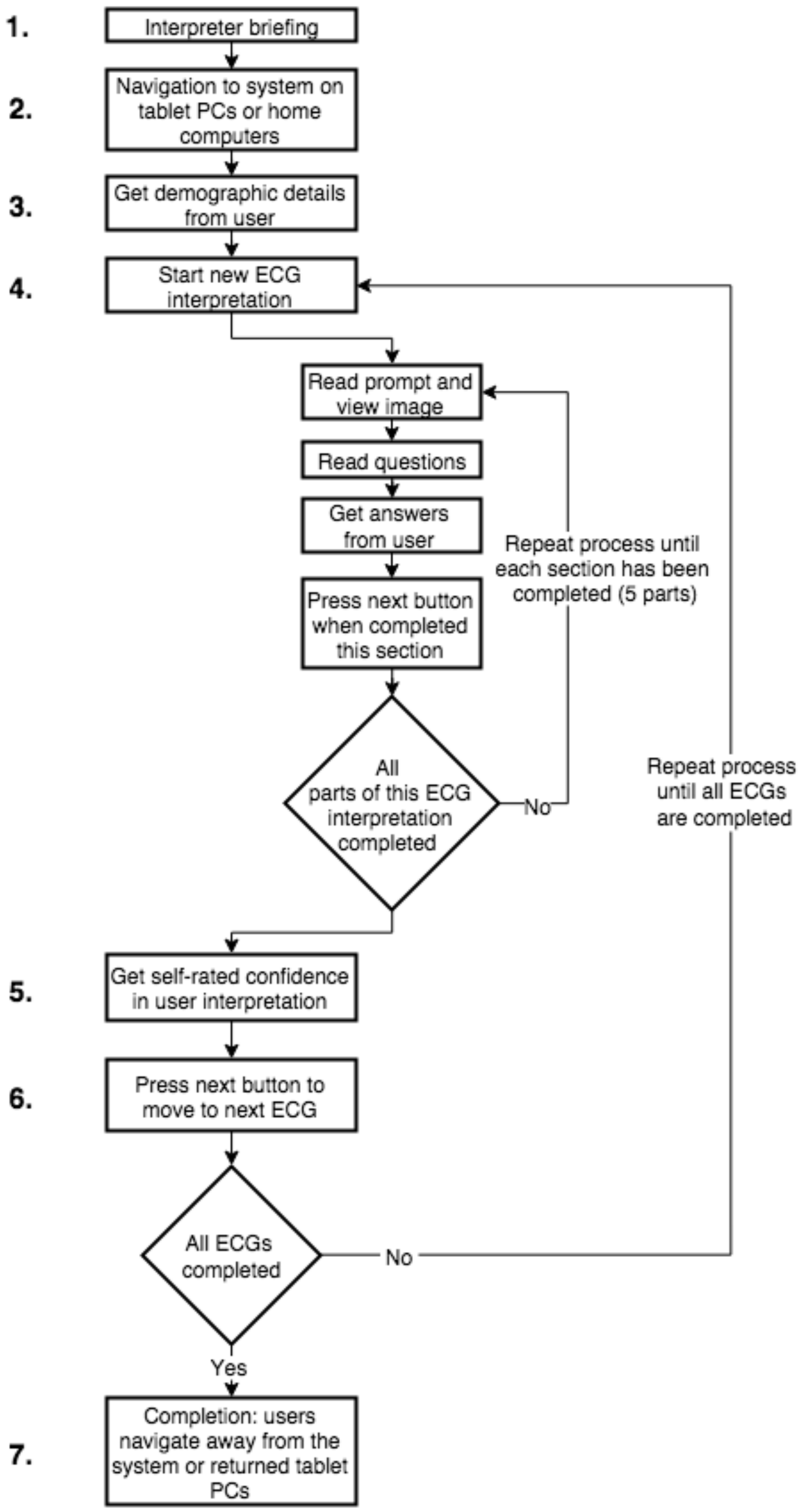

Figure 4.2. Study protocol. 1), interpreter brief, 2) navigation to system URL, 3) demographic collection, 4) begin interpretation, 5) collect self-confidence of interpretation, 6) iteration through remaining ECGs, 7) finish and navigate away from the system.

4.3 Selected ECGs for interpretation

A total of ten ECGs were selected for this study. Table 4.1 provides a description of these ECGs alongside diagnoses and interpretation difficulty level. A specific range of ECGs were chosen to reflect the European Society of Cardiology (ESC) Core Curriculum for the General Cardiologist [269] to align with the NHS healthcare science practitioner training programme [270]. ECGs were selected, with varying difficulty levels, from a publically available ECG repository [271]. The order of ECGs presented to interpreters is seen in Figure 4.1, alongside the relative difficulty level. This order was selected to represent the random order of difficulty an interpreter will encounter within practice. Figure 4.1 also highlights this order as an interpreter flow illustration for both cohorts.

Table 4.1: Chosen ECGs accompanied by grouping, interpretation difficulty level and a brief ECG description.

ECG No.	Diagnosis	Difficulty	Description
Acute MI Group			
1	STEMI	Average	STE N100 µV in V4, V5.
Hypertrophy Group			
2	Left Ventricular Hypertrophy	Difficult	LVH by Sokolow–Lyon criteria, atypical STT strain patterns in left lateral leads
3	Right Atrial Enlargement	No rating	No description
Arrhythmia Group			
4	Ventricular Tachycardia	Easy	Wide QRS tachycardia with regular rate N200/s
5	Supraventricular Tachycardia	Average	Narrow QRS tachycardia, rate 200/min, no P waves visible.
6	Atrial Fibrillation	Difficult	Widened QRS (150 ms), excluding one narrow complex that has a delta wave in II and V5. Conduction via left anterolateral accessory pathway (Q waves in I and aVL, broad prominent R wave in V1).
Lead Misplacement/ dextrocardia group			
7	Right Arm - Left Arm Reversal	Easy	Inverted P, QRS and T in I. Leads II and III interchanged. QRS progression in chest leads are normal.
8	Dextrocardia	Average	Inverted P, QRS and T in I. Leads II and III interchanged. Chest lead QRS progression is consistent with dextrocardia.
9	Chest leads placement error (V1-V5 reversal)	Difficult	Tall R in V1 but no other criteria supporting RVH or dextrocardia (No QR in aVR, normal QRS axis, normal progression of QRS in chest leads with the exemption of V1/V5).
Normal			
10	Normal Sinus Rhythm	No rating	No description

STEMI = ST-elevation myocardial infarction; STE = ST-elevation; LVH = Left Ventricular Hypertrophy; RVH = Right Ventricular Hypertrophy;

4.4 Recruitment

Following ethical approval from Ulster University's Faculty of Computing, Engineering and the Built Environment Research Governance Filter Committee, the recruitment of subjects was carried out in two stages. The first stage of recruitment took place at a series of regional workshops that were setup to conduct the study and to subsequently upskill the participants in their ECG interpretation ability. Participants ranged from General Practitioners (GPs) to medical undergraduates and represented a number of different healthcare institutions. The workshops had taken place in three different localities in Northern Ireland between January 2015 and April 2015. Participants were provided with tablet computers during the sessions, which were retrieved afterwards. The tablet computers were pre-directed to an online application displaying either the standard model or IPI model of ECG interpretation. A local network was created via the adoption of an Apple Airport Express using a local server based on an Apple MacBook laptop which was made available at each workshop venue. A model of this system infrastructure can be seen in Figure 4.3.

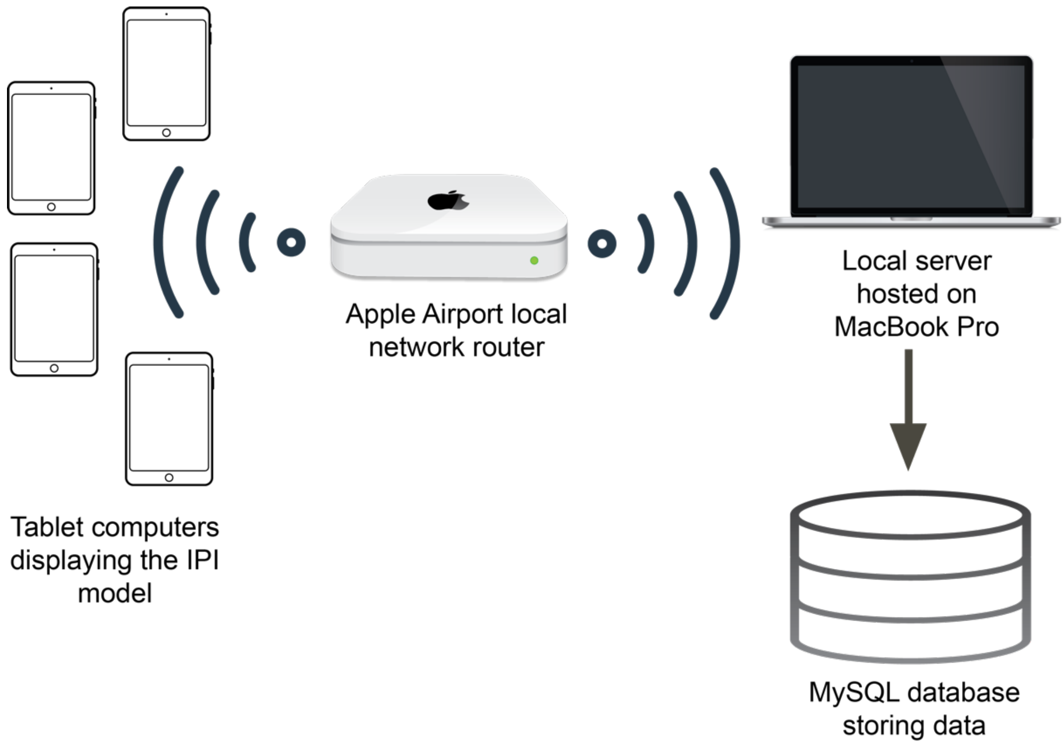

Figure 4.3. System infrastructure used when collecting data from participants in stage one of recruitment

The second stage of recruitment was undertaken remotely. Since the system is device agnostic, it was then uploaded to a live web server and made available on the Internet. This provided the facility to recruit subjects remotely. As a result, delegates who attended the International Society for Computerized Electrocardiology (ISCE) conference in 2014 could participate from that conference venue.

4.5 Data collection

Interpreters were assigned to a cohort manually with the aim of attaining an evenly distributed number of participants in each cohort with similar levels of experience. This method was further informed by the number of interpretations members of each cohort completed. To achieve a comparable number of interpretations in each cohort the number of interpreters within each group became unbalanced.

At the start of each session, all participants were presented with the initial demographics form as shown in Figure 4.4. After subject demographics were submitted the user began interpreting a series of ECGs. The participants were asked to complete at least one ECG interpretation.

Figure 4.4: Demographics collection page interpreters are presented with upon beginning the study. Demographics include: age, gender, occupation, years of experience, and number of ECGs interpreted per year. Interpreters are also asked to enter a trial ID which is provided at the beginning of the study.

4.6 Data analysis

Quantitative data stored on the MySQL database (structure seen in Tables 4.2-4.7), using an Apache web server, was formatted and analysed using a combination of software applications including Microsoft Excel [272] and the R programming language in combination with R Studio [273]. Statistical significance testing was carried out using a two-tailed *t*-test for independent means. The N-1 chi-squared test [274], as recommended by Campbell [275], [276], was used to compare ordinal variables. An alpha value of 0.05 was used to determine statistical significance.

Table 4.2. MySQL database table structure for control questions

Column	Type	Null
id	int(11)	No
ECG_image	text	No
category_id	int(11)	No

Table 4.3. MySQL database table structure for table control users

Column	Type	Null
id	int(11)	No
trial_id	varchar(50)	No
age	varchar(50)	No
gender	varchar(10)	No
occupation	varchar(50)	No
experience	varchar(50)	No
diagnosed_ecgs	varchar(50)	No
user_browser	varchar(50)	No
user_os	varchar(50)	No

Table 4.4. MySQL database table structure for table control_user_answers

Column	Type	Null
id	int(11)	No
user_id	varchar(50)	No
time_start	varchar(50)	No
S5_diagnosis	varchar(200)	No
S5_time_end	varchar(50)	No
conf_level	varchar(2)	No
category_id	varchar(2)	No

Table 4.5. MySQL database table structure for experimental group questions

Column	Type	Null
id	int(11)	No
ECG_image	text	No
category_id	int(11)	No

Table 4.6. MySQL database table structure for experimental group users

Column	Type	Null
id	int(11)	No
trial_id	varchar(50)	No
age	varchar(50)	No
gender	varchar(10)	No
occupation	varchar(50)	No
experience	varchar(50)	No
diagnosed_ecgs	varchar(50)	No
user_browser	varchar(50)	No
user_os	varchar(50)	No

Table 4.7. MySQL database table structure for experimental group answers

Column	Type	Null
id	int(11)	No
user_id	varchar(50)	No
category_id	varchar(50)	No
time_start	varchar(50)	No
S1_Q1_rhythm	varchar(50)	No

S1_Q2_heart_rate	varchar(50)	No
S1_Q3_qrs_association	varchar(50)	No
S1_Q4_sinus_radio	varchar(50)	No
S1_Q5_sinus	varchar(50)	No
S1_time_end	varchar(50)	No
S2_Q1_Pwave	varchar(50)	No
S2_Q2_Pwave_duration	varchar(50)	No
S2_Q3_PR_interval	varchar(50)	No
S2_Q4_heart_block	varchar(50)	No
S2_Q5_Pwave_normal	varchar(50)	No
S2_Q6_atrial_enlargement	varchar(50)	No
S2_time_end	varchar(50)	No
S3_Q1_axis_value	varchar(50)	No
S3_Q2_abnormality_radio	varchar(50)	No
S3_Q3_abnormality_value	varchar(50)	No
S3_time_end	varchar(50)	No
S4_Q1_QRS_duration	varchar(50)	No
S4_Q2_QRS_not_normal	varchar(50)	No
S4_Q3_QT	varchar(50)	No
S4_Q4_R	varchar(50)	No
S4_Q5_QTc	varchar(50)	No
S4_Q6_abnormality_radio	varchar(50)	No
S4_Q7_abnormality_value	varchar(50)	No
S4_time_end	varchar(50)	No
S5_Q1_R_wave	varchar(50)	No
S5_Q2_chest_lead	varchar(50)	No
S5_Q3_limb_lead	varchar(50)	No
S5_diagnosis	varchar(200)	No
S5_time_end	varchar(50)	No
conf_level	varchar(50)	No

4.7 Results

A total of 31 participants were recruited for the study, of which 11 were control participants and 20 used the IPI system as seen in Table 4.9. The average age of the control cohort was 36 years (SD = 13 years) and the IPI cohort was 41 years (SD = 14 years). A total of 48% of participants defined their occupation as a General Practitioner (GP) or a hospital doctor. The interpreter demographics are detailed in Table 4.8 and the interpreter experience is detailed in Figure 4.5. In total, 183 interpretations were made (control cohort = 110, IPI cohort = 73). The demographic for the 'number of ECGs interpreted per year' was collected using banded categories. Therefore, the 'mode' is the method most suitable to represent this data. However, this may not be the most transparent way of representing the cohort. In future developments of the system a scalable data collection method will be used.

Table 4.8. Interpreter occupation distribution in both the control cohort and the IPI cohort

Profile feature	Control Cohort	IPI Cohort
Age	Mean = 36.2 years (SD=13.2 years)	Mean = 40.9 years (SD=13.5 years)
Gender	3 female/8 male	4 female/ 16 male
Experience	Mean = 10.2 years (SD= 10.9 years)	Mean = 12.1 years (SD = 10.6 years)
No. of ECGs interpreted in the last year	Mode > 10 years	Mode > 100 years

Table 4.9: Interpreter demographics for both cohorts showing: average age, gender distribution, average experience and mode of the number of ECGs interpreted in the last year.

Interpreter Occupation	**Control**	**IPI**
GP	3	5
SPR	1	1
Hospital doctor	2	3
Nurse	0	2
Medical student	5	2
ECG researcher	*0*	*7*
Total =	*11*	*20*
Total participants =		31

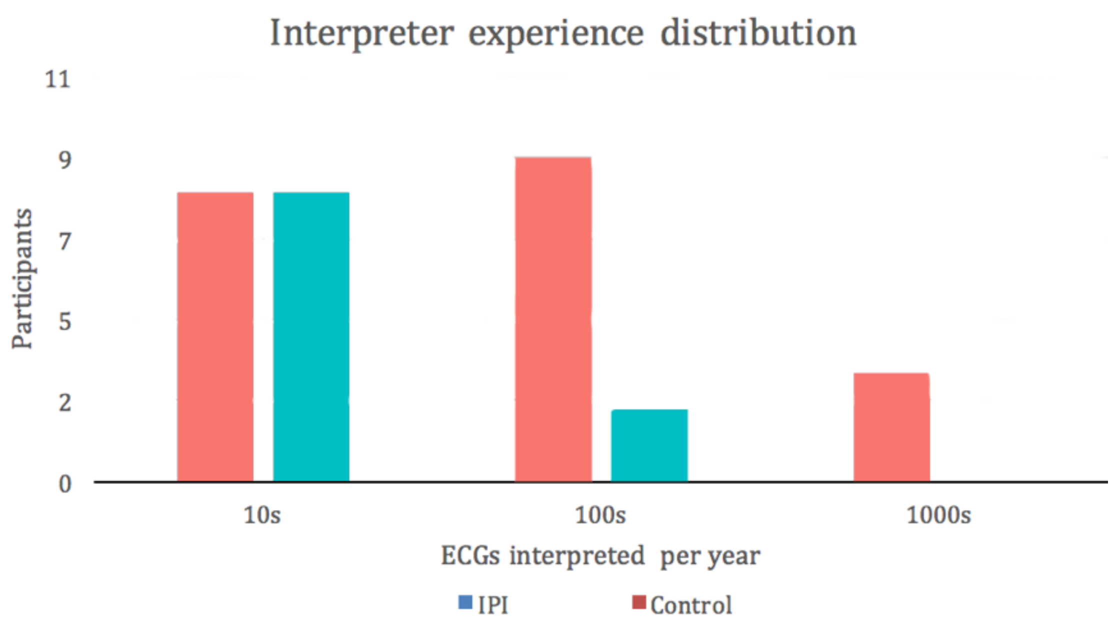

Figure 4.5: ECG interpreter experience distribution between cohorts.

4.7.1 Interpretation accuracy

When looking at the interpretation accuracy rate on a per subject basis, the average subject accuracy rate for the control cohort was 45.45% (SD = 18.1%; *CI =42.07, 48.83*). The average accuracy rate in the IPI cohort was 58.85% (SD = 42.4%; *CI = 49.12, 68.58*), which indicates an average accuracy rate increase by 13.4% (CI = *4.45, 22.35*). The large standard deviation may be a result of the varied competency and experience of interpreters within each cohort. When considering interpreters in the IPI cohort who engaged with the system, interpreting more than two ECGs (n=6), the average accuracy rose to 71% (SD=33) indicating an average accuracy rate increase of 25.4% (CI = -0.22, 24.52). An N-1 Chi-square test of independence indicated that there is an 84% chance the control cohort and the IPI cohort are different and a 92% chance the IPI cohort will have a higher accuracy rate. Following individual ECG analysis it was discovered that only ECGs with a diagnosis of a STEMI or Supraventricular Tachycardia (SVT) obtained a greater average accuracy interpretation using the control approach as seen in Figure 4.6. Thus, the IPI approach improved diagnostic accuracy in the remaining eight diagnoses.

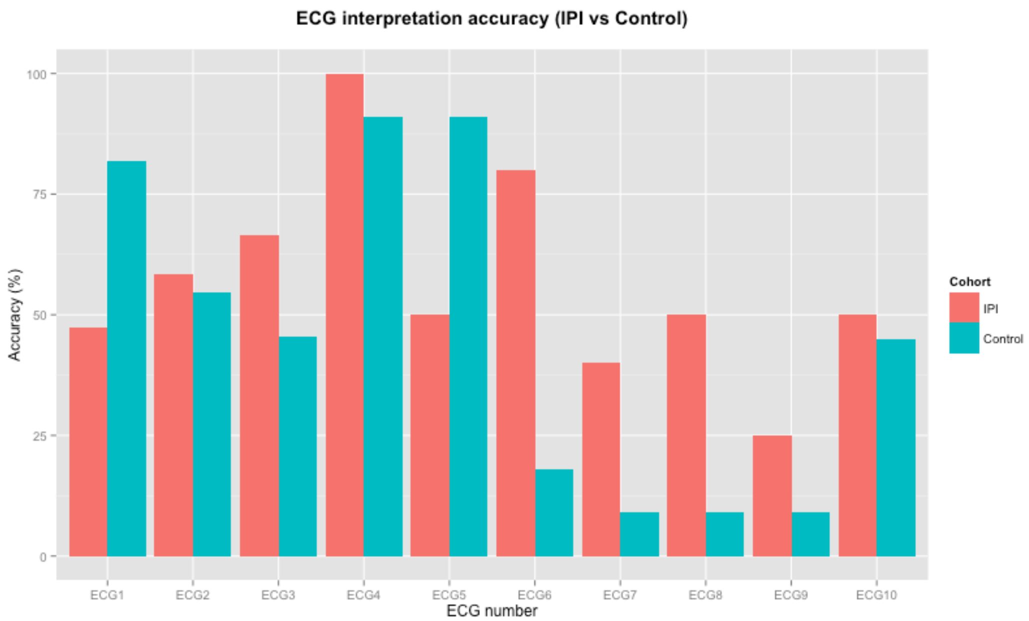

Figure 4.6. A comparison of average interpretation accuracy for each ECG in both the control cohort and the IPI cohort.

4.7.2 Interpreter self-rated confidence

After each ECG interpretation each interpreter was required to provide a confidence rating for their final interpretation of that ECG. This requirement was to determine if there was a correlation between the self-rated confidence and the accuracy of the interpretation itself. The control cohort has an average self-rated confidence rating of 4.9/10. The average self-rated confidence rating for the IPI cohort per subject is 6.1/10, which indicates that the IPI cohort had a slight increase in confidence. This was found to be not significant ($t = 1.98$, $p = 0.06$) but did illustrate a trend.

By comparing ECG confidence levels using boxplots for each cohort we see a marked improvement in the cohorts using the IPI system for each ECG diagnoses. The interpretation for the STEMI ECG was the only ECG to render a reduced average confidence level, Figure 4.7. Interpreters were least confident interpreting the ECG presenting right atrial enlargement in the control cohort (mean = 3.6, SD=1.9). However, confidence more than doubled in the IPI cohort (mean = 7.3, SD = 1.6). This increase was found to be statistically significant ($t = 4.07725$, $p < 0.05$).

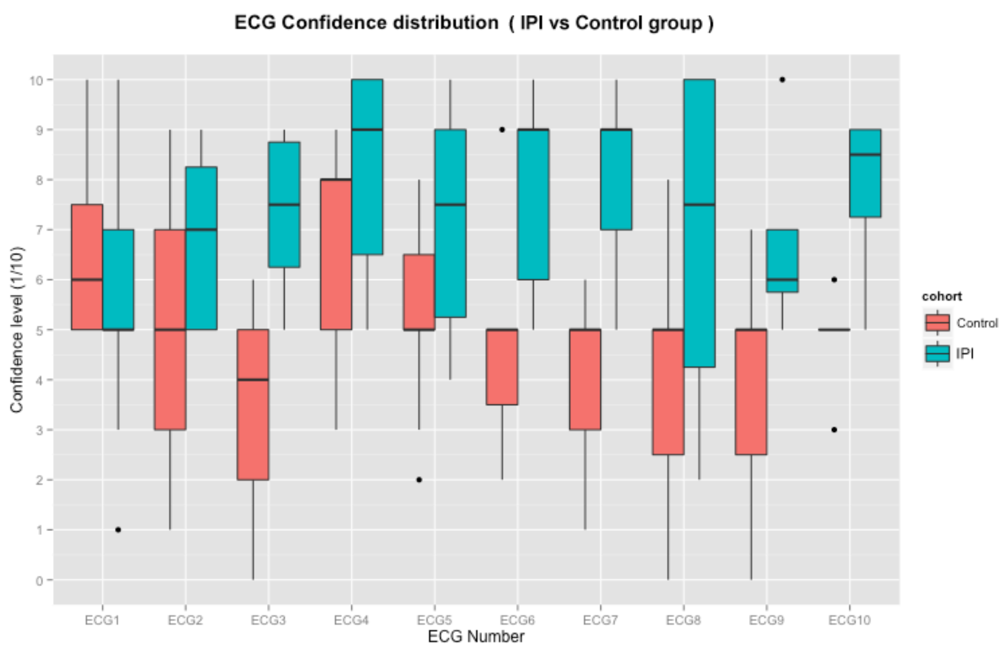

Figure 4.7. A distribution comparison for self-rated confidence for ECG interpretations between both the control cohort and the IPI cohort.

When assessing confidence correct/incorrect distribution we discover the average correct confidence is 8.4 in the IPI cohort compared to 5.0 in the control cohort. This indicates that interpreters are more confident their interpretation will be correct using the IPI system. However, we also discover incorrect interpretation confidence increases marginally from 4.8 in the control cohort to 5.8 in the IPI cohort. As noted previously, these results illustrate interpretation confidence increases overall. However, these results also allude to interpreter self-confidence being greater in interpretations which match the correct diagnoses, as seen in Figure 4.8a and Figure 4.8b.

These results reflect published research which illustrates how computerised decision support (specifically algorithms which provide a computerised interpretation) can have a misleading effect on the interpreter. Cognitive bias created by CDSS's can also influence other factors including accuracy. Interestingly, this method of CDSS increases interpreter self-confidence in interpretations which match the correct diagnoses which may indicate incorporating the human in the digital interpretation process may lead to more confident clinicians, or make this method of ECG interpretation useful as a training methodology to help students gain confidence in their ECG annotation and interpretation.

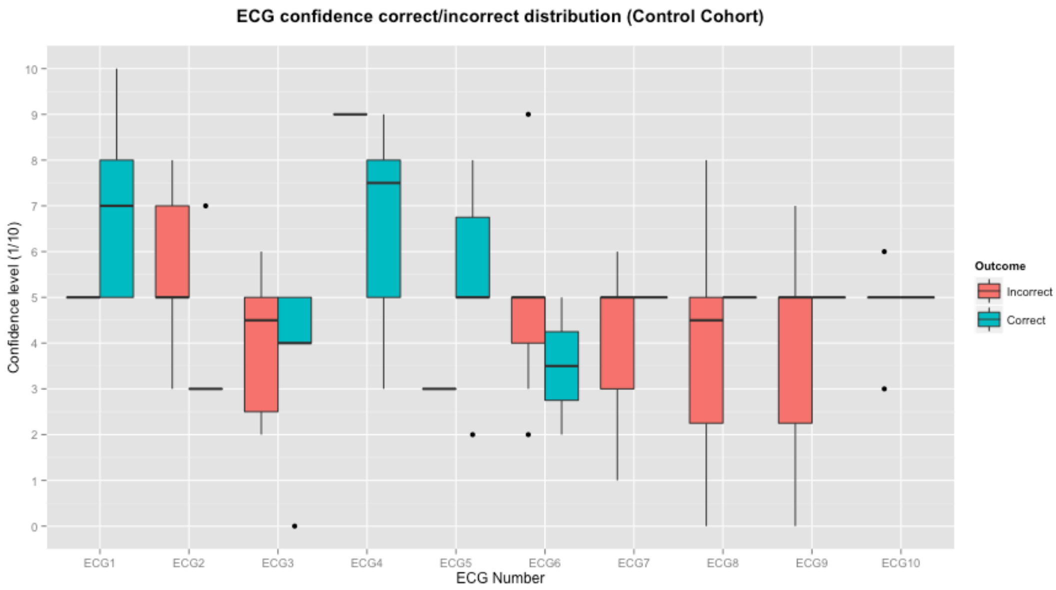

Figure 4.8a. ECG confidence correct/incorrect distribution in the control cohort.

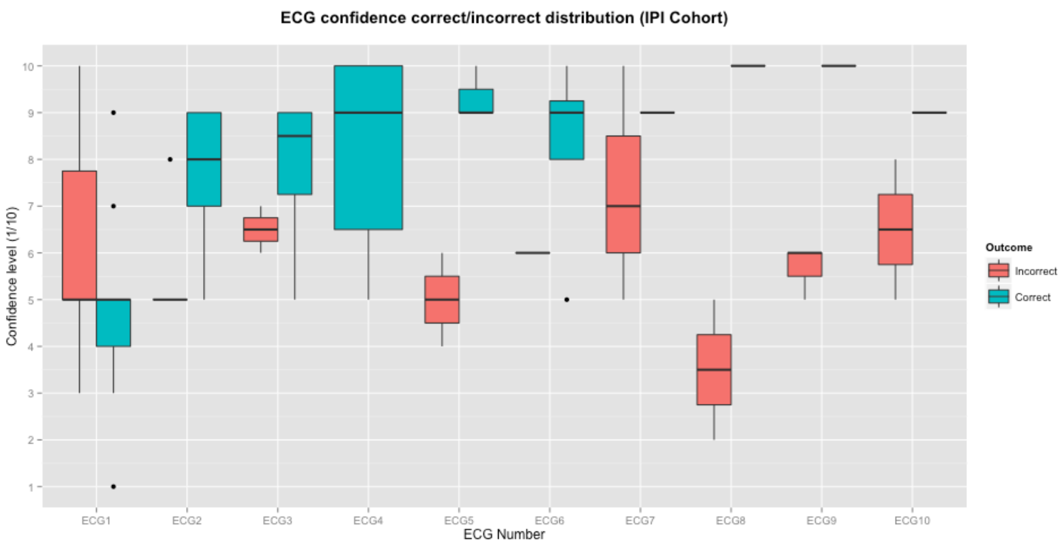

Figure 4.8b. ECG confidence correct/incorrect distribution in the IPI cohort indicating interpretation confidence increased overall but increases greater in correct interpretations.

4.7.3 Interpretation duration

The average subject duration per ECG in the control cohort, excluding outliers, was 119.56 seconds. However, the average duration, excluding outliers, was 712.28 seconds in the cohort who used the IPI system to interpret the same ECGs. These results indicate that with the IPI system, in its current version, it takes six times longer to interpret the same ECG when compared to the standard approach to ECG interpretation. This is expected as the one-stage task of analysing an ECG has been segmented into 5 components, each containing numerous subcomponents. Results indicating duration distribution per ECG in each cohort are shown in Figure 4.9.

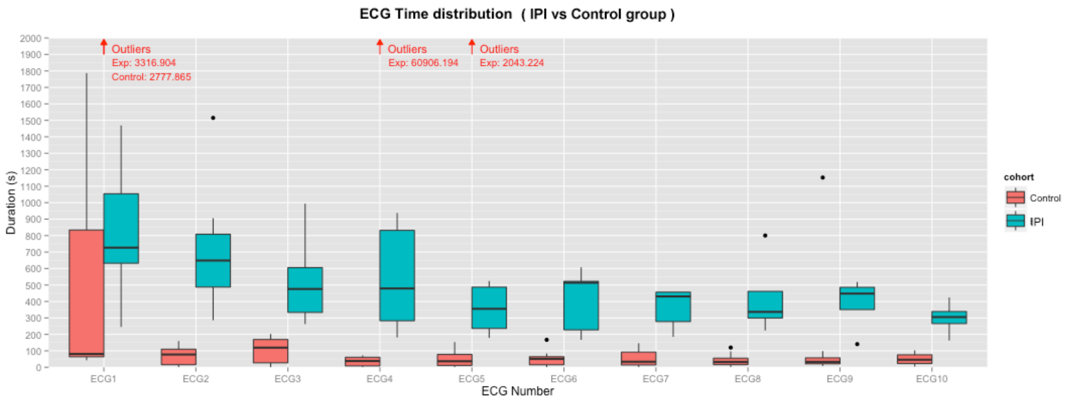

Figure 4.9: ECG interpretation duration distribution per ECG between the control cohort and the IPI cohort.

4.7.4 Interpretation Correlation

Correlations between interpretation accuracy and confidence have been calculated using the Pearson Product-Moment Correlation Coefficient. A weak correlation was found in the control cohort (r=0.22, p =0.02, n=110 CI = 0.035, 0.391) whilst in the IPI cohort there was a moderate correlation (r=0.53, p<0.0001, n=73, CI = 0.342, 0.677). Thus, there is a stronger relationship between self-rated confidence level and the interpretation accuracy in the IPI cohort. In summary, it indicates that self-rated confidence of those who used the IPI model is a better predictor for diagnostic accuracy.

One factor which could indicate a stronger correlation between the accuracy and confidence in the IPI cohort could be the result of a longer, more focused, ECG interpretation duration on each ECG. Therefore, correlation between interpretation accuracy and duration has also been assessed. It was found statistically significant correlation was not present in either the control cohort (r=0.07, p =0.44, n=110 CI = -0.118, 0.253) or the IPI cohort (r=0.14, p =0.25, n=73, CI = -0.093, 0.358). This indicates any additional time spent interpreting an ECG using the IPI approach was not found to yield improved ECG interpretation accuracy compared to the time required in normal ECG interpretation. We also found no strong or moderate correlation between the duration of an interpretation and the interpreter's confidence rating (control cohort (r=0.03, p =0.02, n=110, CI = -0.158, 0.216) and the IPI cohort (r=0.11, p =0.36, n=73, CI =-0.123, 0.331)).

4.7.5 Interpretation agreement

A further experiment was undertaken to determine ECG interpretation agreement in both the control cohort and the IPI cohort. Common methods of computing agreement such as Cohan's Kappa, Fleiss' generalised kappa or Scott's Pi [277] are unsuitable for this dataset due to missing values as a result of participant dropout. However, Krippendorff's Alpha has been proposed as the standard reliability statistic as it meets all desired properties for agreement assessment [277]–[280]. It was found that the control cohort has an agreement of 0.0251. When using the IPI system interpretation agreement was similar and found to be 0.0256. In the case of this study, the expected Krippendorff's α required to determine agreement is $\alpha > 0.667$. The very low α statistic in both the control cohort and IPI cohort highlights enormous variability in ECG reporting terminology. This is evidenced in the 41 different diagnoses given for the 10 ECGs utilised in this study across both cohorts.

4.7.6 Segment analysis

Segment duration analysis, as seen in Figure 4.10, highlights segment four in the IPI model is a bottleneck in terms of the average duration it requires for interpretation. Segment four assesses the QRS morphology and interpreters are presented with the chest leads. This extended average time is to be expected as the QRS morphology represents the most complex array of deflections in a normal ECG. To help assess morphology changes over time the rhythm strip was also presented as a secondary image. This examination of the rhythm strip as a secondary ECG image may also have led to the extension of time in this segment. As seen in Figure 4.11, segment one requires the most time to complete for the ECGs 4, 5 and 6. This is expected as segment one assesses the rhythm strip and these three ECGs each presented an arrhythmia.

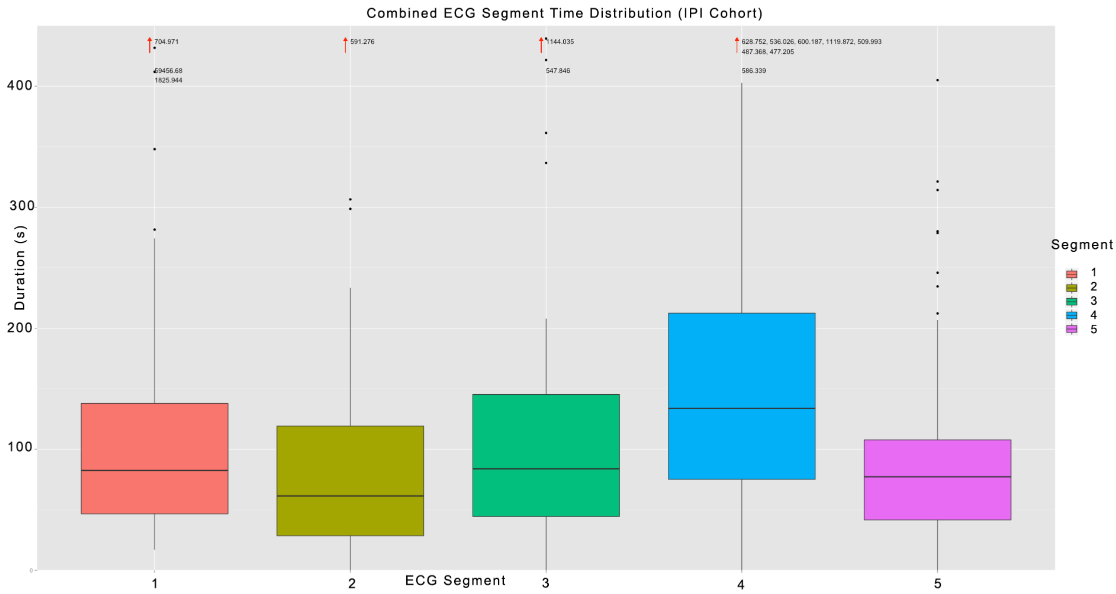

Figure 4.10. ECG segment analysis showing the average duration spent on each segment of the IPI system.

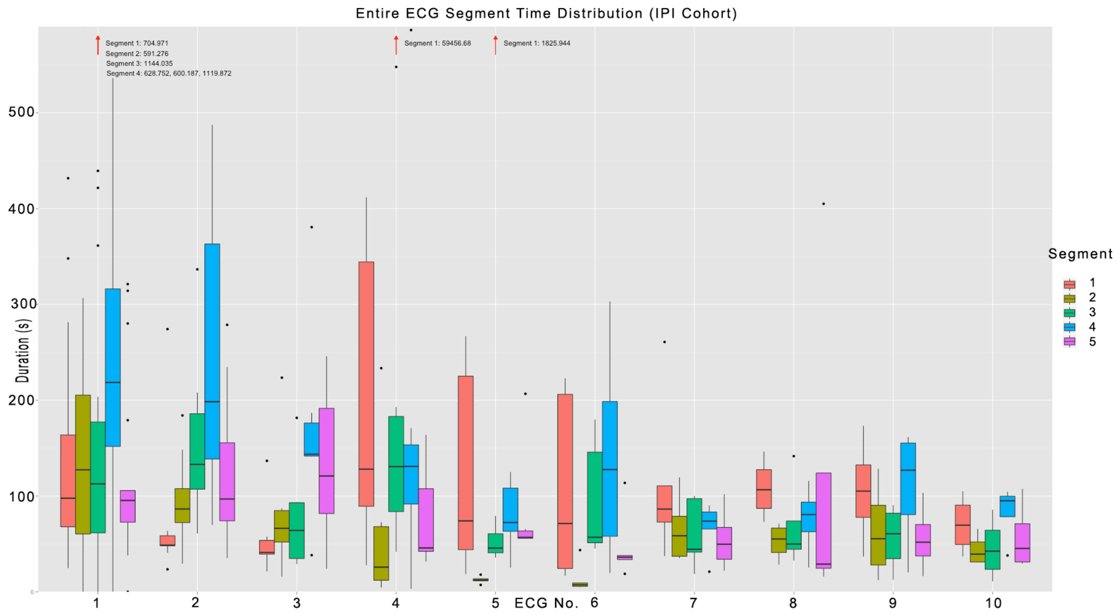

Figure 4.11. ECG segment analysis showing the average duration spent on each segment for each ECG for interpreters using the IPI system.

4.7.7 Learning effect

Figure 4.12 shows that interpretation duration reduces throughout the IPI cohort as more ECGs are interpreted, thus indicating fast system adoption. In the IPI cohort the average interpretation duration of ECG ten (299.5s) was three times faster to interpret than ECG one (952.63s). This indicates a 68.6% duration reduction between ECG one and ECG ten. Thus, indicating a gradual duration reduction across all ECGs as the system becomes increasingly familiar to the interpreter.

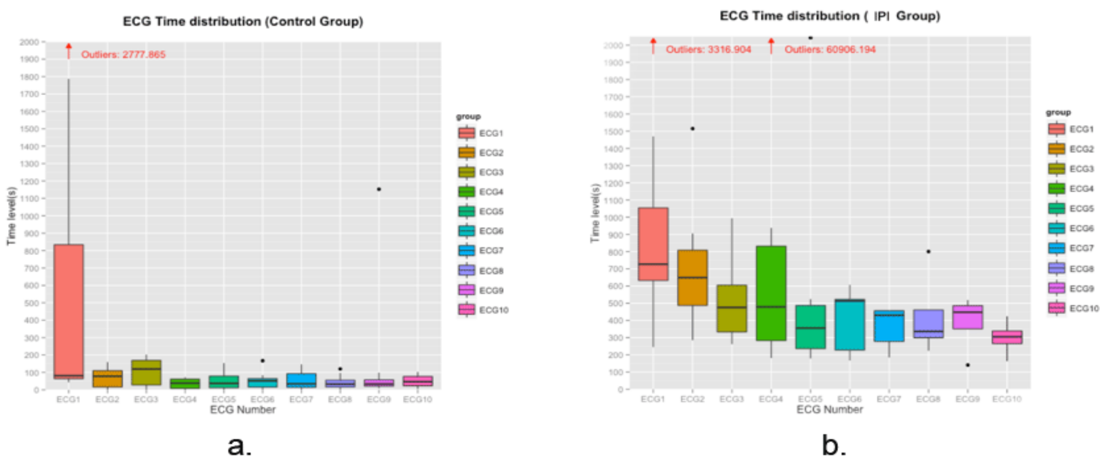

Figure 4.12a (Control group) and 4.12b (IPI group): ECG interpretation duration showing a reduction in interpretation time as interpreters' progress through each ECG in each system.

4.7.8 Variability of human annotations of 12-lead

Imprecise and inconsistent human annotations can affect both the reader's diagnostic decision making, and the accuracy of diagnoses suggested by any computerised algorithm (junk in = junk out). Further research has been conducted on a subset of participants who completed most the same number of interpretations using both the conventional method and the IPI method. Clinical physiology students (n=10) and medical practitioners (n=11).

It was discovered students annotated more features (5/8) with less variance (refer to Table 4.10, Figure 4.13 and 4.14). Students annotate interval measurements with 47% less variation than medical practitioners (Σ interval measurement; students SD=0.36, practitioners SD=0.68). Students also had less variation in measuring heart rate, P-wave amplitude and cardiac axis. Two of the annotated features (QT-interval and QTc) from both cohorts had statistically significant differences ($p \leq 0.05$).

Table 4.10. Student vs practitioner annotation variation in standard deviation

Annotation	**Student**	**Medical Practitioner**
HR	mean= 88.7bpm, SD=4.27	mean= 91.4bpm, SD=14.68
P duration	mean= 0.09s, SD=0.03	mean= 0.08s, SD=0.01
P amp	mean=0.19mv, SD=0.05	mean=0.18mv, SD=0.3
PR interval	mean= 0.18s, SD=0.05	mean= 0.16s, SD=0.03
Axis	mean=60°, SD=0	mean= 51.5°, SD=18.8
QT	mean=0.41s, SD=0.06	mean= 0.24s, SD=0.17
RR	mean=0.72s, SD=0.13	mean= 0.53s, SD=0.27
QTc	mean=0.48s, SD=0.09	mean= 0.33s, SD=0.2

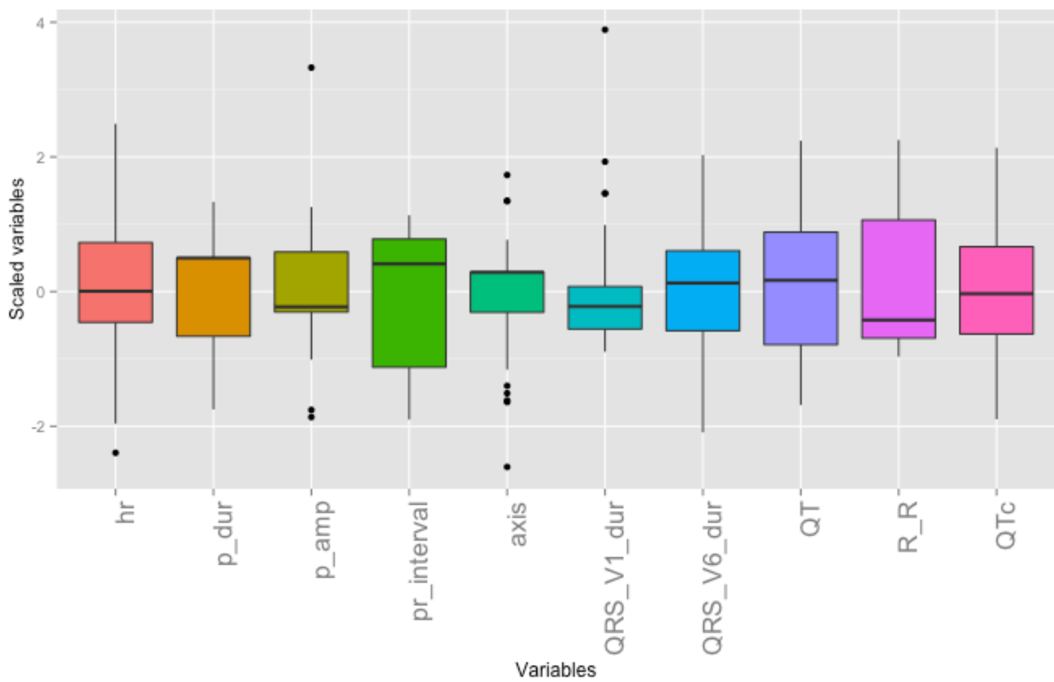

Figure 4.13. Box plot showing variation in student cohort

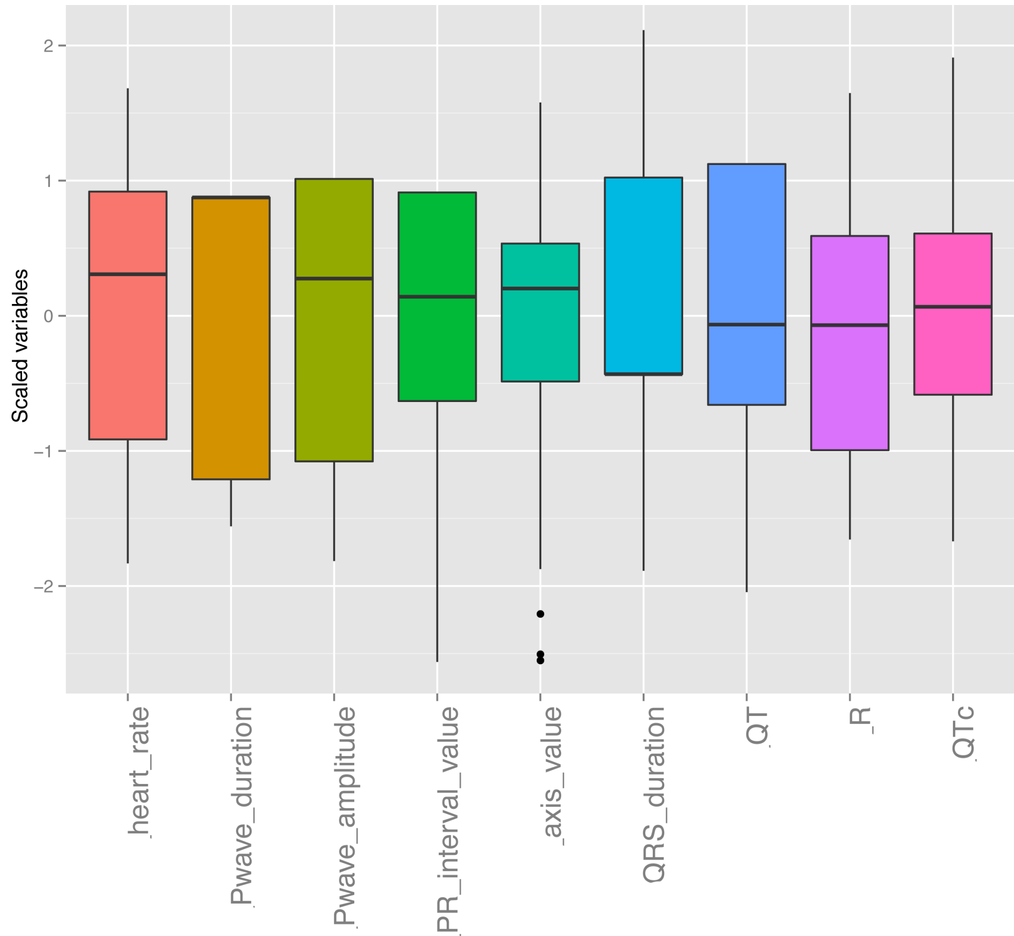

Figure 4.14. Box plot showing variation in medical practitioner cohort

Resulting performance was not assessed as the practitioner cohort was a selection of different occupations including; GPs, nurses, cardiologists and scientists each of which has varying levels of clinical experience interpreting an ECG.

4.8 Discussion

Novice interpreters are known to follow a systematic approach to ECG interpretation [8], [16] however it is generally recognised that ECG interpretation by an experienced interpreter follows a two stage protocol, initial perception based on intuition followed by a systematic approach [8], [72], [95]. This allows the interpreter to identify co-abnormalities which are often overlooked when the clinician relies solely on their first impression. This phenomenon has been coined ‘early satisfaction syndrome’ [8]. By employing the IPI interpretation approach, ECG interpreters are guided and required to systematically interpret ECGs, which reduces information overload and manages the clinician's cognitive load. Thus abnormalities, and co-abnormalities, could not easily be overlooked. During this study it was discovered using the IPI interpretation approach diagnostic accuracy increases in final ECG interpretation at the expense of diagnostic time. Therefore, by adapting the clinical interpretation process to follow a sequential approach, across a series of interactive web pages, interpreter diagnostic accuracy increases. It is speculated that one such cause of this interpretation accuracy improvement is due to interpreters being forced to spend extra time assessing individual deflections and morphology changes as expected during typical novice ECG protocol. It was also discovered there was a large variability in ECG reporting terminology but the current IPI model did not significantly reduce inter-rater variability.

However, as expected the duration of an entire ECG interpretation was found to be significantly longer. This extension of interpretation duration is likely to be too time intensive in a clinical diagnosis scenario, despite enhanced accuracy. Nevertheless, the ability to increase interpreter diagnostic accuracy in ECG interpretation could allow the IPI system to be used in other capacities. Such a system can be used as a rigorous ECG reporting protocol, a teaching or training tool or for use in an ECG core lab requiring precise manual interpretation.

This study also determined the variability of manual ECG annotations on a cohort containing both students and practitioners. The annotations with most variance included P-wave measurements, the QT segment and the RR segment. Therefore, we have highlighted potential areas of focus for future CDSS, i.e. the human, or computerised, measurements of these intervals. It is also noted, in this study students outperformed medical practitioners in annotation recording. This may indicate the value placed upon ECG interpretation features within education has an impact on the quality of annotations that students record. Conversely, qualified practitioners may forgo ECG annotations in routine practice and therefore annotation quality diminishes.

The drop-out rate of participants using the IPI system has also been noted. This could result from several factors. 1) the workshops used for some interpreter participation may not have been entirely appropriate for ECG interpretation 2) Initial technical issues regarding the wireless internet connection 3) The current development state of the IPI system design. The current version of the system design may have influenced interpreter completion rates due to tiresome input requirements. These are further expanded upon in the thesis limitations, 7.4.1.

4.9 Conclusion

To assess whether ECG diagnostic accuracy can be improved through exploiting the provision of interactive touch screen devices, a system was developed that presents a segmented 12-lead ECG across five web-based graphical user interfaces. This digitisation facilitates an intuitive deconstruction of a complicated task (interpretation of the ECG) into sub-tasks which in turn can improve human performance and diagnostic accuracy. Following analysis, it is recommended that interpreters adopt a sequential system for the interpretation of ECGs – even cases exhibiting 'obvious' symptoms. Thus, categorisation of distinct steps within the interpretation procedure serves as a checklist to facilitate the eradication of missed co-abnormalities during ECG interpretation. With the upcoming digitisation of the NHS [27] it has been discovered that ECG interpretation errors can be reduced using clinician-friendly interactive touch screen systems that assist the interpreter in their clinical decision-making processes.

4.9.1 Further research

An enhancement to the proposed system could be the implementation of a feature that automatically digitises and segments an image of an ECG since this is manually done for the current IPI system. Similarly, a potential addition to this model is the development of a rule-based system to assist the interpreter's final diagnoses. This could be achieved using rules that would use the inputted data received from the interpreter to provide relevant ECG diagnoses for the clinician to consider. Contrary to current computerised diagnostics in electrocardiography, we hypothesise that providing multiple diagnoses for the interpreter to consider will increase diagnostic accuracy since the suggestion of multiple options alleviates certain cognitive biases such as confirmation bias [281]–[283] and anchoring [284]. With this in mind, Chapter 5 will outline the design of a system to use these human annotations of the ECG to provide computerised diagnoses/interpretations.

Chapter 5:
An Annotation Driven Rule-based Algorithm for Suggesting Multiple 12-lead ECG Interpretations

5.1. Introduction

As outlined in Chapters 2, 3 and 4, CVD is regarded as a substantial economic and medical burden around the world [1], [285]. To help combat this, diagnostic tools such as the Electrocardiogram (ECG) are used to help clinicians detect cardiac abnormalities. However, as previously identified in chapter 2 this format of electrocardiographic presentation can offer 'knee-jerk' reactions in interpretations and a significant cognitive load.
To help alleviate this cognitive workload and to decrease diagnostic time, this format of ECG presentation is often supplemented by computer analysis. This involves presenting the interpreter with an automatically generated ECG interpretation and diagnosis. Routinely, computerised ECG diagnostics is composed of four main steps; 1) Signal pre-processing, 2) QRS detection, 3) feature extraction and 4) signal classification [168]. However, computerised analysis of severe cardiac conditions such as Acute Myocardial Infarction (40.7% error rate) and upper degree AV blocks (75% error rate) are often inaccurate [65]. Many previous investigations into computerised ECG diagnostics corroborate and indicate the unreliability of computerised diagnoses, often highlighting wide variations in false-positive and false negative identification of STEMI [196]. This unreliability can lead to both improper use of medical resources and adverse patient treatment planning [19], [74], [169], [170]. Therefore, computerised ECG interpretation should always be over-read by a clinician, especially in non-sinus rhythms [74].

Furthermore, since current computerised ECG interpretation often only provides a single diagnosis, it can contribute to a number of cognitive biases, (1) anchoring bias (fixation on a premature suggestion/answer/diagnosis/interpretation), (2) confirmation bias (seeking features/annotations to confirm rather than falsify a diagnosis) or (3) premature closure (acceptance of a diagnosis before verification) [18], [21]. Novotny et al. highlights in his paper on the role of computerized diagnostic proposals in the interpretation of the 12-lead electrocardiogram [94] that accuracy is significantly influenced when a single diagnostic proposal is presented. He continues to find bias a significant influencing factor when comparing correct/incorrect diagnostic proposals as he states, "giving the correct diagnosis improves the accuracy while giving a wrong diagnosis lowers the accuracy”. Finally Novotny also noticed when multiple computerised diagnostic proposals were presented to interpreters diagnostic accuracy improved [94].

To combat these concerns and to provide a de-biasing strategy [286]–[288], a decision support algorithm has been developed to provide multiple potential ECG diagnoses. The provision of annotation data resulting from interpreters using the IPI method to analyse an ECG created the opportunity to draw comparisons between annotations and recognised diagnostic criteria. Thus, this model can be described as a data-driven and rule-based approach to ECG interpretation. Differential diagnoses algorithms have been used extensively throughout medicine to systematically reach a conclusion. Specifically in electrocardiology these algorithms are often used in the interpretation of sub-components of the ECG, often arrhythmias (i.e. diagnosis of wide QRS complex tachycardia) . However, the interpretation of an entire 12-lead ECG using a human annotated approach has not been implemented thus far.
In this case, by presenting multiple possible interpretations is likely to encourage a differential diagnosis. Moreover, since the algorithm is semi-automatic and is based on features (annotations) inputted by the human interpreter, we hypothesis that the algorithm may have greater accuracy when compared to conventional computer ECG diagnostics. This is due to conventional algorithms focusing on automatically extracted features from signals that are often noisy and difficult to process [74] .

5.2. Model design

The algorithm builds on previous research highlighted in Chapter 3 and 4, in which the IPI model has been described, by augmenting the interpretation process with potential suggested answers before requiring final diagnoses from an interpreter. The potential augmentation of the IPI system arose from the recognition of annotation data being recorded. As described, the IPI model de-constructs 12-lead ECG interpretation into five sub-components each consisting of structured questions presented over five sequential web-based user-interfaces. It was discerned the annotation data could be utilised and if dynamic comparisons could be made to a predefined set of recognised diagnostic criteria. As a rule-based approach offers accountability, transparency and evident logic, it is a frequently used approach within medicine. Moreover, rules derived for a system can often be encoded directly from guidelines or criteria themselves. Consequently, a diagnostic criteria dataset was generated from medical electrocardiography textbooks, research papers, and expert judgements from both academics and clinicians. Through this facilitation, a set of logical rules could be implemented to form a comparative strategy between human annotations and recognised diagnostic criteria. This laid the foundation of the rule-based decision support algorithm.

One constraint of this method of rule creation is maintaining a consensus between recommended diagnostic criteria from different institutions, academics and medical professionals as each may be independently variable. This challenge has been mediated through the procurement of multiple literary and human resources combined to determine a consensus.

A data-driven method of decision support was considered, however a data-driven approach requires large datasets with gold standard interpretations for machine learning to take place. A dataset of this type was not readily available, and as machine learning can lack both accountability a transparency this approach was not undertaken.

The design of these segments have been updated from previous iterations to improve user interaction, can be seen in Figures 5.1-5.5, and are as follows; *Segment 1: Interpretation of the rhythm strip (Figure 5.1), Segment 2: Interpretation of the P-wave morphology (Figure 5.2), Segment 3: Interpretation of the limb leads (Figure* ***5.****3), Segment 4: Interpretation of the QRS morphology (Figure 5.4a and 5.4b), Segment 5: Review the full 12-lead ECG to assess R wave progression and lead misplacement (Figure 5.5a and 5.5b).* To improve user interaction by reducing annotation input times all text fields have been removed and replaced with interactive sliders for range data, buttons, tabs, among other novel input methods (cardiac axis wheel input, Figure 5.3). These features aim to reduce interpretation time by eliminating keyboard typing which can be both error prone and time consuming, especially on a mobile device. Further UI changes include the colour scheme to help improve user response to action items (i.e. buttons) and layout reconstruction to facilitate a more efficient user experience. These changes are influenced by a number of factors, including; feedback from participants in the IPI study, evaluation of annotation times within the IPI study, and intentions of maintaining contemporary web design standards, best practises and design techniques.

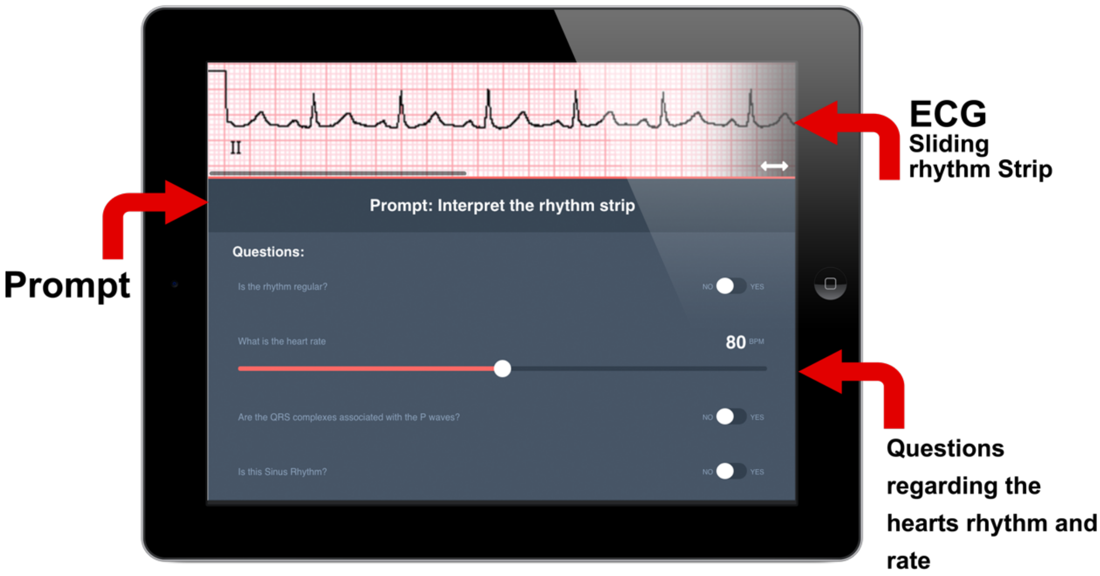

Figure 5.1. IPI model screen 1: Interpretation of the rhythm strip

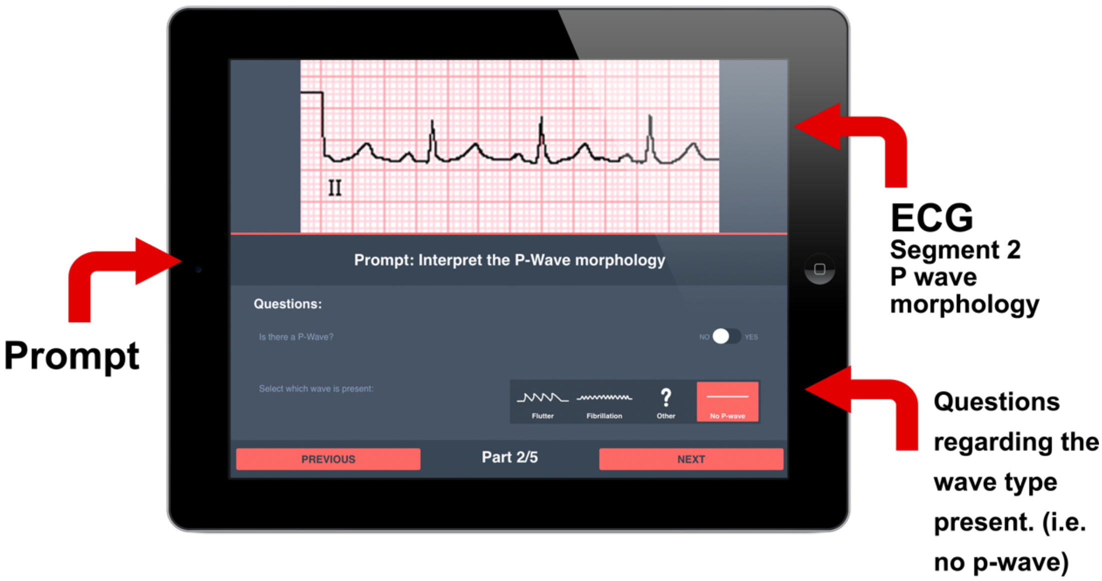

Figure 5.2. IPI model screen 2: Interpretation of the P-wave morphology

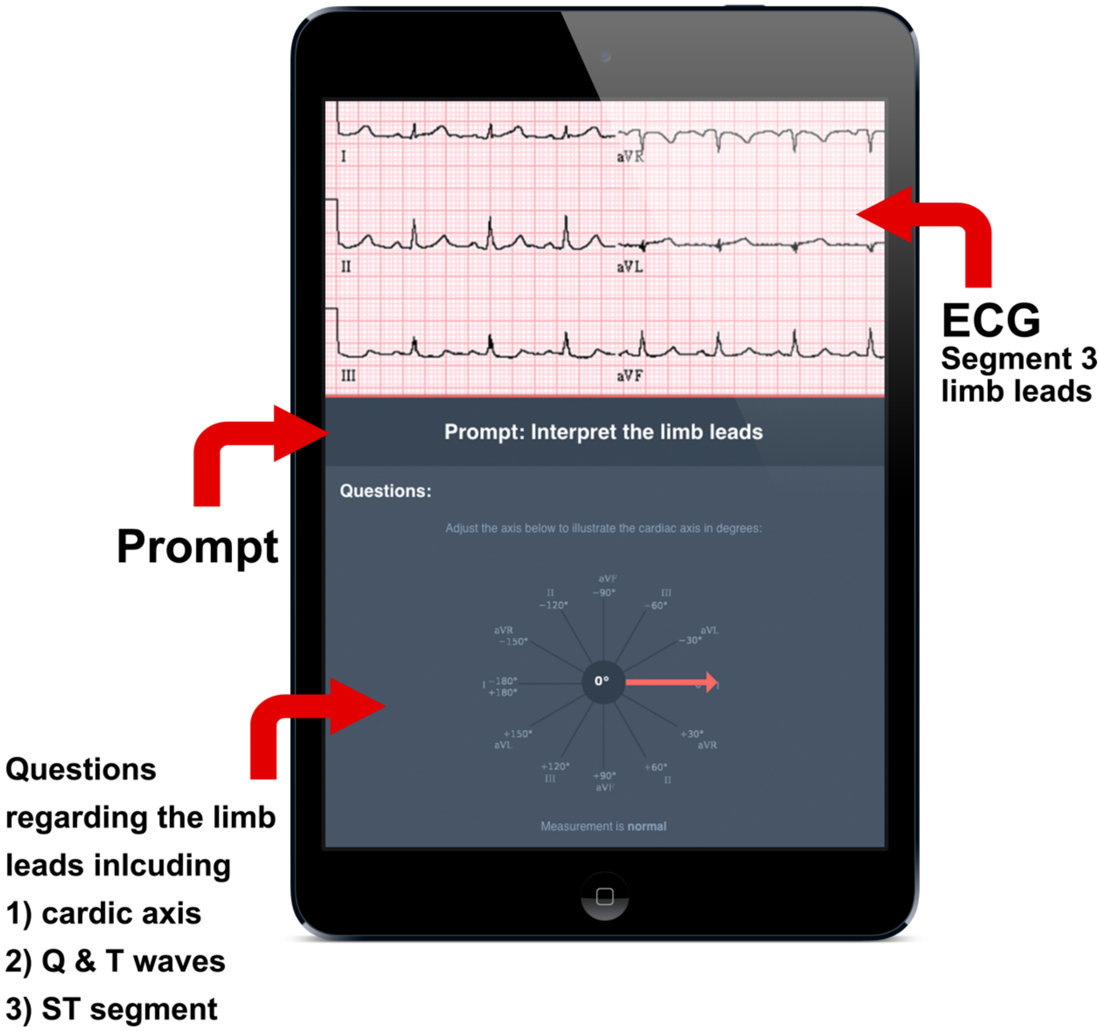

Figure 5.3. IPI model screen 3: Interpretation of the limb leads including an interactive axis chart allowing users to dynamically adjust the hearts cardiac axis

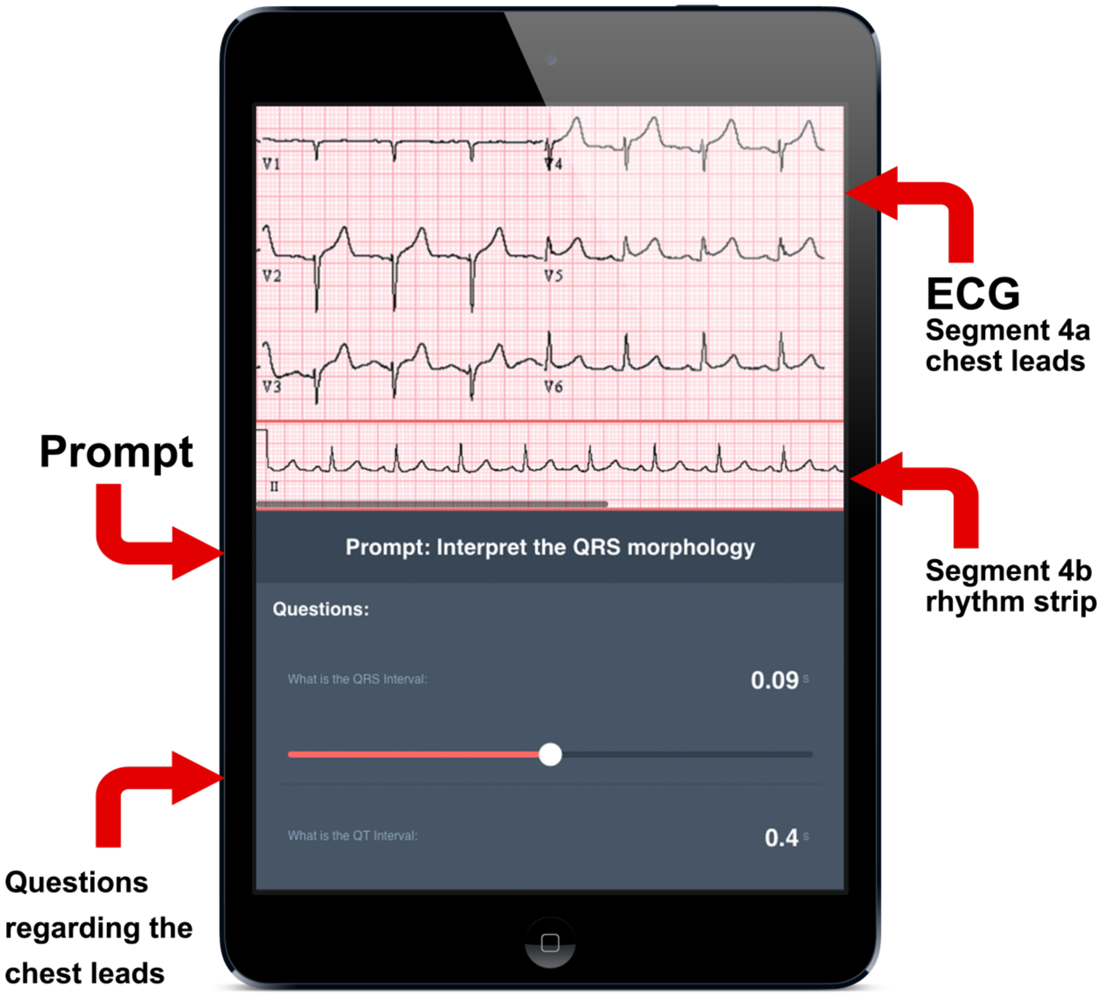

Figure 5.4a. IPI model segment 4: Interpretation of the QRS morphology. Segment 4 shows both the chest leads and the rhythm strip

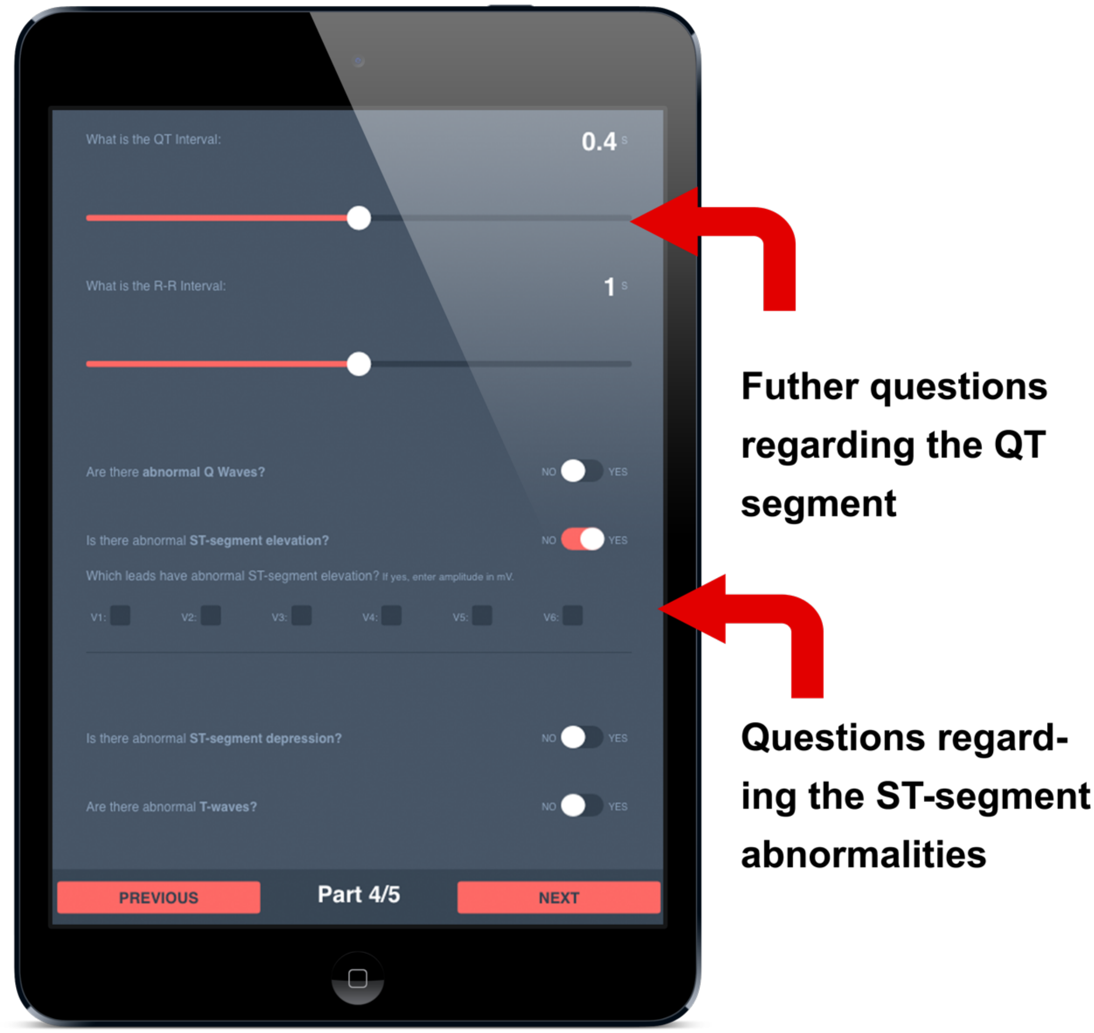

Figure 5.4b. IPI model segment 4: Interpretation of the QRS morphology. Segment 4 also asks questions regarding the Q-wave T-wave and ST segment

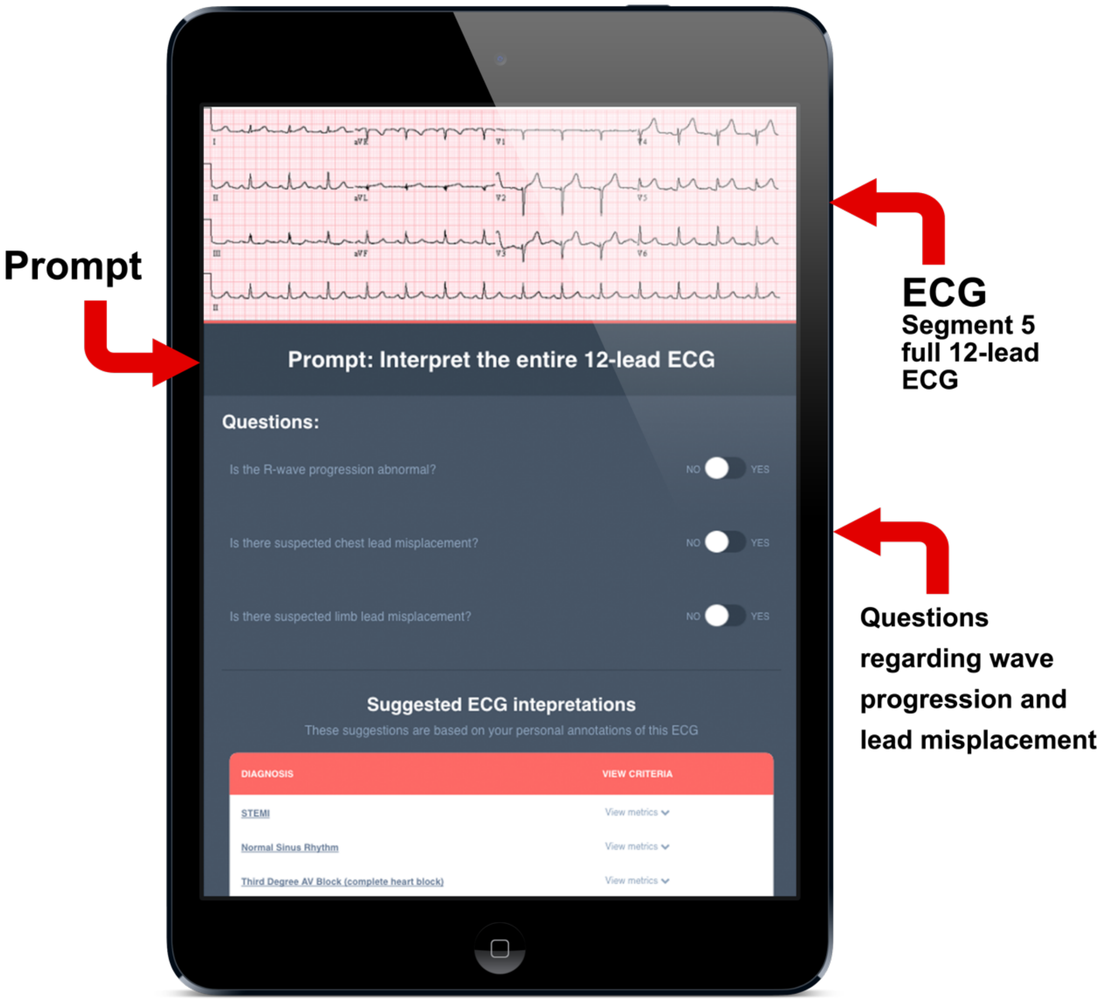

Figure 5.5a. IPI model screen 5: Review the full 12-lead ECG including questions about the R-wave progression and lead misplacement

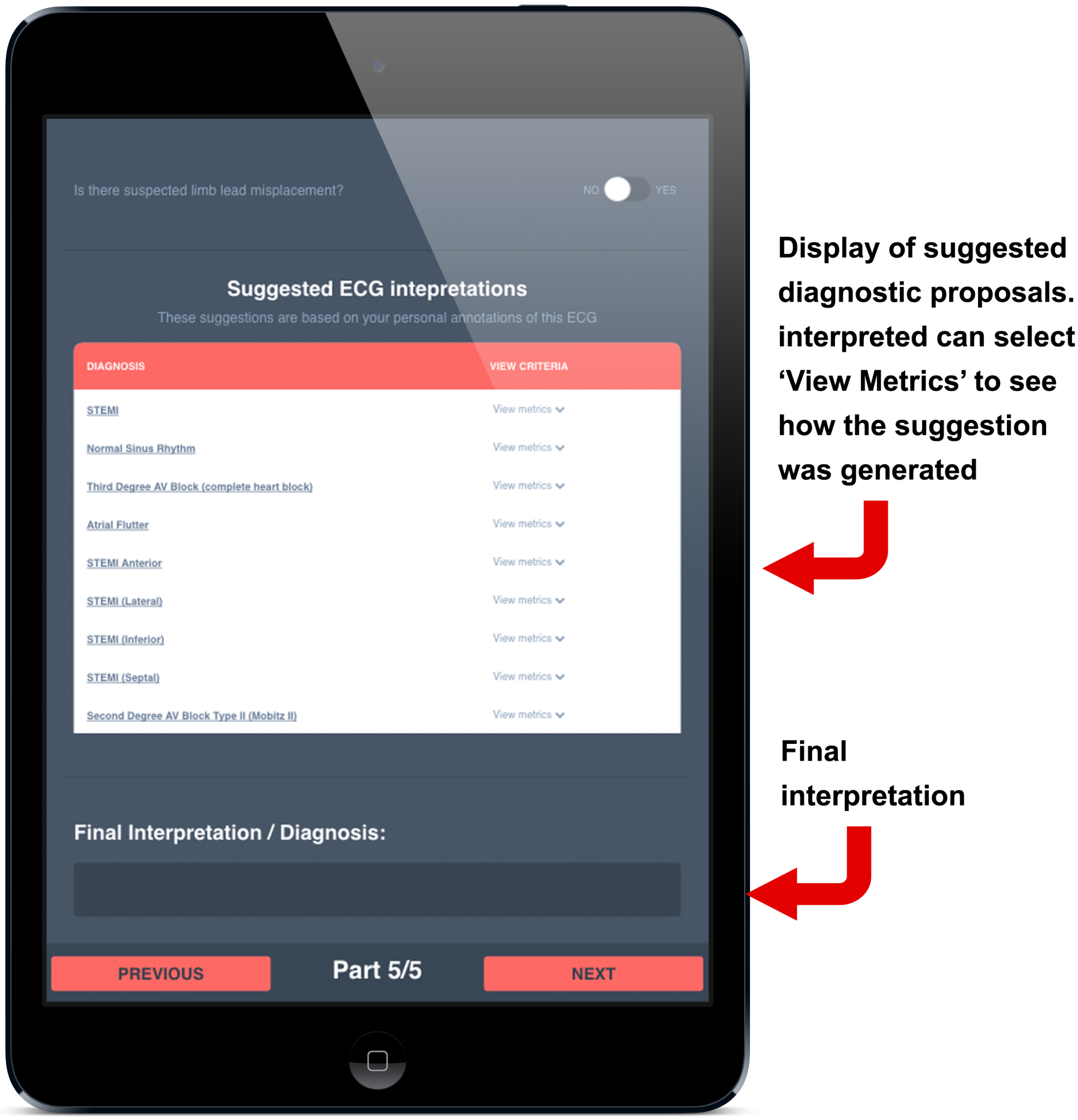

Figure 5.5b. IPI model screen 5: Review the full 12-lead ECG. This segment also presents suggested diagnostic proposals for interpreter consideration. An interpreter can view metrics to understand how the algorithm came to relative suggestions.

Following assessment of all ECG reporting components for all five segments, Segment 5 was augmented with the Differential Diagnoses Algorithm (DDA), wherein a set of potential ECG diagnoses is presented to an interpreter, based on their own interpretation annotations. To encourage a differential diagnosis, the list of potential ECG diagnoses is accompanied with diagnostic criteria. After considering these diagnoses, this segment requires a conclusive interpretation to be provided by the interpreter.

5.3. Methodology

The DDA was developed using emerging web technologies to allow the best possible user experience and to facilitate ubiquitously access across devices and platforms. Hypertext Mark-up Language version 5 (HTML5) was implemented to present and structure webpages across various web browsers, while Cascading Style Sheets (CSS3) were used to create an engaging user experience. The programming language of the web, JavaScript, along with the subsidiary JQuery library, was used to allow interactive participation from interpreters. This was implemented via reactive animations when collecting or presenting data, or interpreter annotations. All data and interpreter annotations are collected via toggling buttons or sliding range inputs. All data is saved to a MySQL database through the implementation of Asynchronous JavaScript and XML (AJAX) and the Hypertext Pre-processing language (PHP).

JavaScript Object Notation (JSON) was chosen to store ECG Rule criteria for the DDA. JSON was selected as the preferred storage format due to it being a lightweight data-interchange format. Although it uses the JavaScript syntax it is also a language independent data structure, and therefore could be integrated directly in both the server-side and client-side elements of a system [289]. Previous research proposed the eXtensible Markup Language (XML) to represent ECG criteria (refer to ecgRuleML, [225]), however JSON allows a compressed structure facilitating efficient access and computation from various sources including web-based systems. If semantically annotated, structured JSON data is a self-describing human-readable data format. i.e. both human and machine interpreters can read/interpret a dataset and identify that the document contains information referring to an ECG [290]. JavaScript was used to implement the rule-based algorithm, which collects interpreter annotations and uses the JSON criteria to match these annotations against a possible diagnosis. The algorithm searches, filters and returns potential ECG diagnoses from the ECG criteria JSON data object. These results are then rendered onto segment 5 of the IPI system through adding HTML5 elements using the jQuery 'append()' method in real-time.

A rule-based algorithm is executed upon each response to a question to produce automatic diagnostic suggestions. The algorithm first performs annotation validation and formatting. Subsequently, the algorithm conducts searches on a JSON data object file for ECG diagnostic criteria in order to presented any matches to an interpreter's current set of annotations. It then returns a list of ECG names arranged by the frequency of matches between interpreter annotations and recognised ECG criterion. Upon toggling a button or sliding a range input, the algorithm is invoked and the following series of events occur;

1) a variable is created and assigned the annotation value from the button press or range input
2) an array is created for each variable which is populated later in the process
3) once these declarations have been made, a request is made to load data from a JSON file stored on a web-server
    3a) the request searches the data file for ECG diagnostic criteria matching the assigned variables at each given stage of interpretation
    3b) once matching criteria has been identified the name of the ECG with matching criterion is deposited in the relevant variable arrays which were previously declared
4) each array is then deposited inside a master array
5) to enable a presentation of ECG names based on the percentage of matching criteria, unique ECG names were indexed and counted. This arrangement was stored in a key-value paired JavaScript object with the ECG name as the key and a percentage of criteria matches as the value
6) the JavaScript object is then sorted based on the frequency value and deposited into an ordered array.
7) the array is then truncated to only present diagnostic suggestions which match at least 50% of the diagnostic criteria

8) each value in this array is then outputted into an HTML list item and rendered onto Segment 5 of the IPI sequence in the interpreter's browser.

The algorithm will only provide a diagnostic suggestion when the annotations match at least 50% of the diagnostic criteria. Pseudo-code can be seen for this process in Algorithm 5.1**.** A flow diagram of this process is also available in Figure 5.6a, whilst a worked example of this process can be seen in Figure 5.6b.

Algorithm5. 1. Pseudo-code illustrating the algorithm used to generate and present multiple potential ECG diagnoses based on an interpreter's annotations.

```
Algorithm 1: Suggestion algorithm
  Input: Input click event for each question
  begin
      foreach input event do
          Empty suggestion element placeholder
          Data: NewVariable ⟵ Value        /* New variables based on current data values */
          Data: NewVariableArrays ⟵ []      /* Empty variable arrays (populated later) */
          Data: Call to ECG JSON data                              /* .getJSON function */
          foreach variable do
              if variable = ECG criteria (crit) then
                  ReleventECGarray ⟵ crit

          foreach ECGarray do
              MasterArray ⟵ ECGarray

          Data: Create ⟶ MasterObject

          Array to object conversion loop to enable a frequency count
          foreach ECGarray in MasterArray do
              foreach ECGdiagnoses in ECGarray do
                  if ECG diagnoses == false (i.e. does not exist / empty / or 0) then
                      MasterObject ⟵ 0

                  else if Diagnosis is unique then
                       Add diagnoses to MasterObject and add 1 to the count
                      MasterObject ⟵' Diagnosis' : Count = 1

                  else
                       Add count of 1 to relevant Diagnosis
                      MasterObject ⟵' RelevantDiagnosis' : Count + 1

          Convert MasterObject ⟶ SortedArray
          Sort (decending) SortedArray
          foreach Diagnois in SortedArray do
              Output: Diagnosis
```

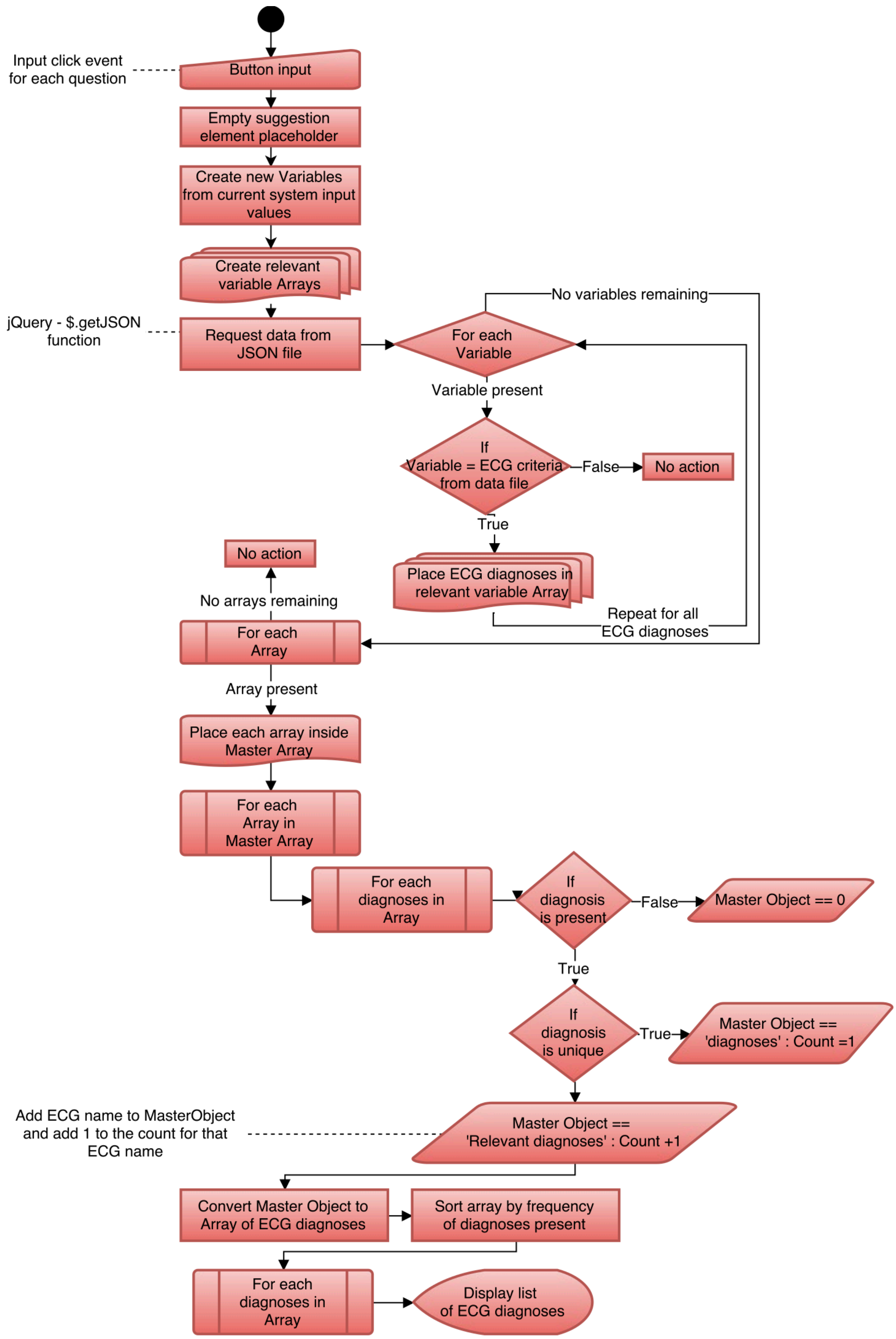

Figure 5.6a. Rule based algorithm flow diagram illustrating the processes undertaken upon an interpreter's interaction with the IPI model

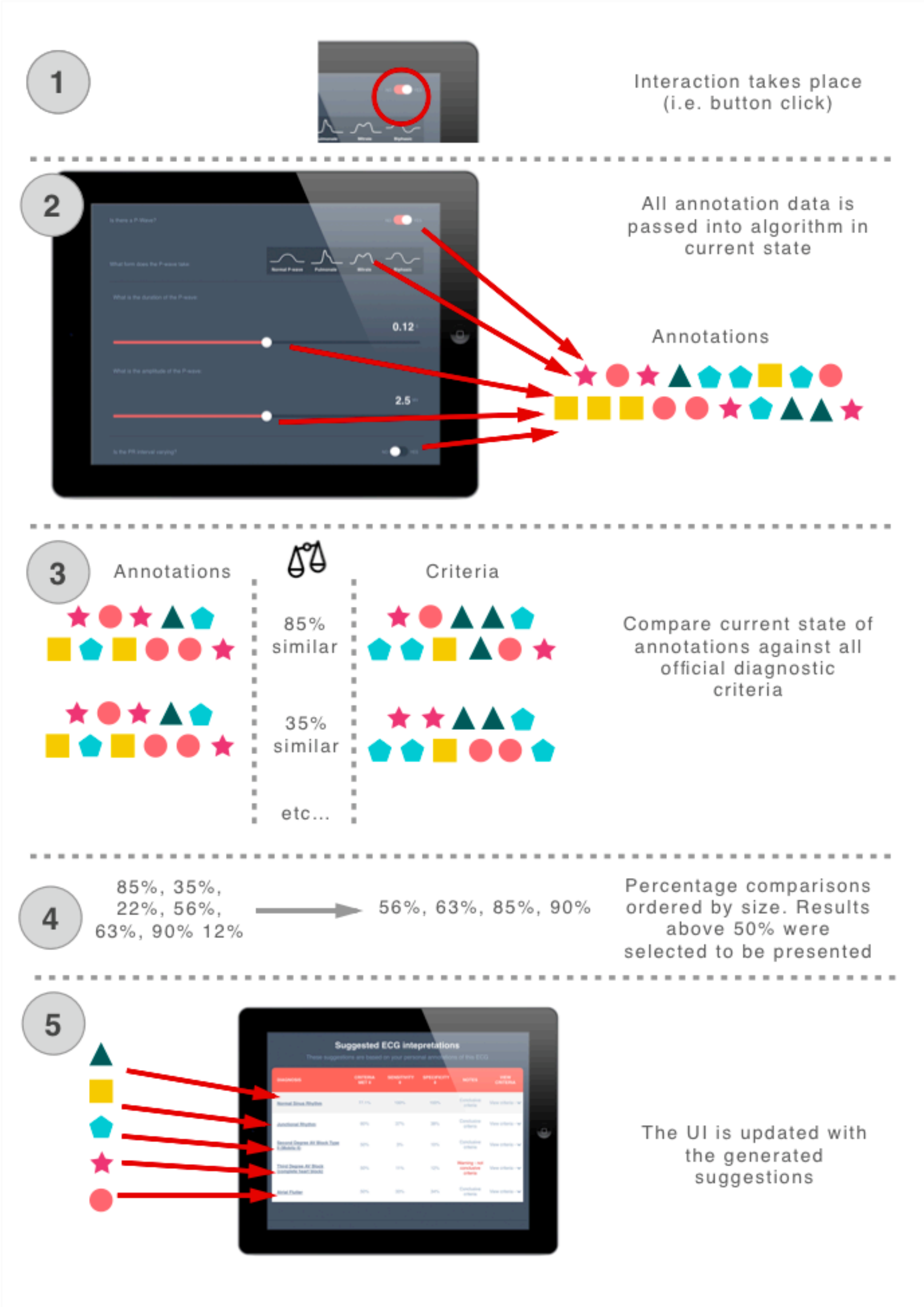

Figure 5.6b. Worked example of this rule-based algorithm process initiated on an interaction (i.e. button click, range slider). Phase 1) user clicks button, 2) annotations collected 3) annotations compared to diagnostic criteria, 4) comparisons sorted and filtered, 5) suggestions presented on webpage

5.4. Differential diagnosis

Provisions have been made if an interpreter requires more information about a suggested diagnosis. When an interpreter selects a diagnosis from the list of suggested diagnoses, a list of diagnostic criteria is displayed for that item. The pseudo-code for this algorithm can be seen in Algorithm 5.2. To achieve this, a number of steps took place; 1) A check is performed to determine if the criteria is currently displayed or hidden. 2a) If the criteria are currently hidden;

- i) A request to load data from the same JSON data file is made. This algorithm searches the data file for an ECG name which corresponds to the selected suggested diagnosis.
- ii) If a match is discovered, each criterion from the selected ECG is returned
- iii) The criteria are then displayed in an unordered HTML list below the selected suggested diagnosis, on the interpreter's browser.

2b) If the criteria are currently displayed;

- i) The criteria are hidden
- ii) The criteria are then removed from the webpage

Algorithm 5.2. Pseudo-code illustrating the differential diagnoses algorithm used to present further diagnostic information to interpreters when making a decision

```
Algorithm 2: Suggestion criteria algorithm
  Input: Input click event for suggested item
  begin
      if data-toggled == "on" then
          Input: Suggested item
          Data: Call to ECG JSON data (data)
          foreach ECG in data do
              if ECG name == Suggested item then
                  foreach ECG in data do
                      Data: ECG Criteria
              Output: Attach and show ECG criteria to element
      else if data-toggled == "off" then
          Empty Empty suggestion criteria element placeholder
          Output: Hide ECG criteria to element
```

We hypothesise that this DDA algorithm provides a supplement of multiple potential diagnoses and could reduce cognitive biases during diagnosis. The list of suggested diagnoses with relative criteria, facilitates differential diagnosis by an interpreter based on the interpreter's ECG annotations. Thus, this is a potential optimal man-machine model for ECG interpretation since the human is better at recognising patterns and shapes in noisy signals whereas the machine is better at reasoning based on a large set of rules. The suggestion algorithm also provides the opportunity for self-validation and can in addition act as a safety mechanism to help identify missed co-abnormalities.

5.5. JSON structure

The JSON data file was created in a format to allow a semantically structured information hierarchy. Other eXtensible Markup Language (XML) data structures have been created in this way to store ECG datasets (ecgML[291], ecgRuleML[225] and XML-BSPM [292]). Each dataset contains an ID, ECG diagnosis name, ECG diagnosis grouping, a list of diagnostic criteria and references. An example JSON structure can be seen in Figure 5.7, full JSON source code can be seen in Appendix B.

Excerpt from ECG_criteria.json


```
    {
        "id": 10,
        "name": "Normal Sinus Rhythm",
"group": "normal",
        "criteria": {
            "regular_rhythm": "Regular",
            "HR": "Normal",
            "P_QRS_association": "Yes",
            "sinus": "Yes",
            "P_wave": "Present",
            "PR_interval_variation": "Constant",
            "qrs_interval_v1": "Normal",
            "qrs_interval_v6": "Normal",
            "qrs_axis": "normal deviation",
            "aVR_normality": "Normal",
            "QT_interval": "Normal",
            "t_wave_inversion_leadI": "No",
            "t_wave_inversion": "No",
            "r_progress": "Yes"
        },
        "criteria_references":  "Criteria:  Surawicz  B,  Knilans  TK.  Chou's
Electrocardiography in Clinical Practice. 6th Edition.
    }
```


Figure 5.7. Example JSON structure describing diagnostic criteria for dextrocardia

5.6. Human annotation variation reduction

As highlighted in Chapter 3 we discovered a large variation in terminology when an interpreter gave an annotations or diagnoses to an ECG. To reduce the number of terminology variations a number of strategies have been employed. Firstly, free text entry systems have been reduced to one (final interpretation), and have been replaced with quantitative annotation collection methods such as; range sliders (Figure 5.8), radio buttons (Figure 5.9 and 5.10), check boxes (Figure 5.10), icon bars (Figures 5.11a and 5.11b, note; these update automatically based on user interaction), and interactive charts (Figure 5.12). Secondly, a further method of annotation variation reduction includes an automatic-tagging tool developed to engage with an interpreter when using the final interpretation free-text entry box. Similar to a folksonomy, where users apply 'tags' to items, this auto-tagging tool uses the name of a cardiac disease or condition as a tag. Therefore, when a user begins to type their final interpretation the tool searches and filters a JSON file for a diagnostic condition which contains the same series of letters. These conditions are then presented in an interactive selection area enabling interpreters to select the interpretation they began to type. This process could both reduce time required to provide a diagnosis, and reduce variations in terminology used by interpreters. This system can be seen in Figure 5.13a and 5.13b.

Figure 5.8. Example range slider showing how an interpreter would adjust a heart-rate annotation

Figure 5.9. Example radio button showing how an interpreter would select if the rhythm is regular (not selected in example)

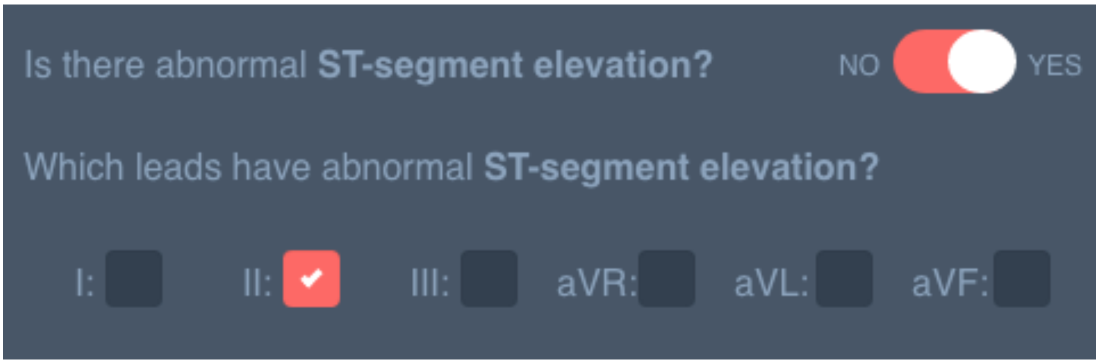

Figure 5.10. Example radio button showing how an interpreter would select if abnormal ST-elevation is present (selected in example). Figure also illustrates checkbox selection for which lead displays abnormal ST-segment elevations (lead II in example)

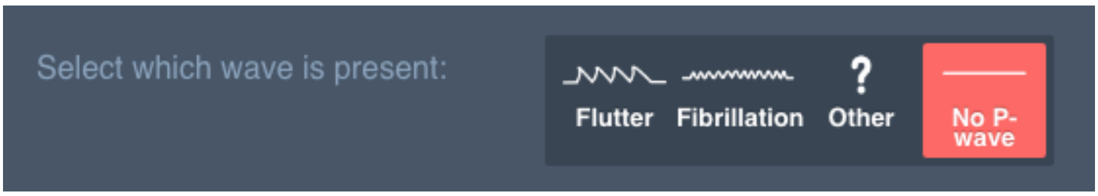

Figure 5.11a. Example icon bar showing how an interpreter would select which wave is present (no wave is present in this example)

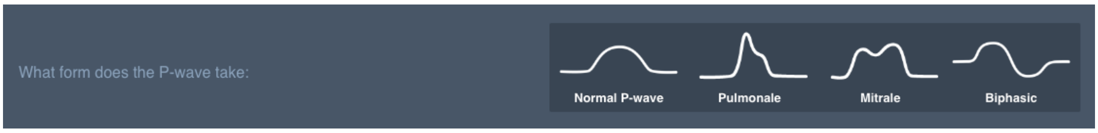

Figure 5.11b. Example icon bar showing how an interpreter would select which form the P-wave takes (no selection in this example)

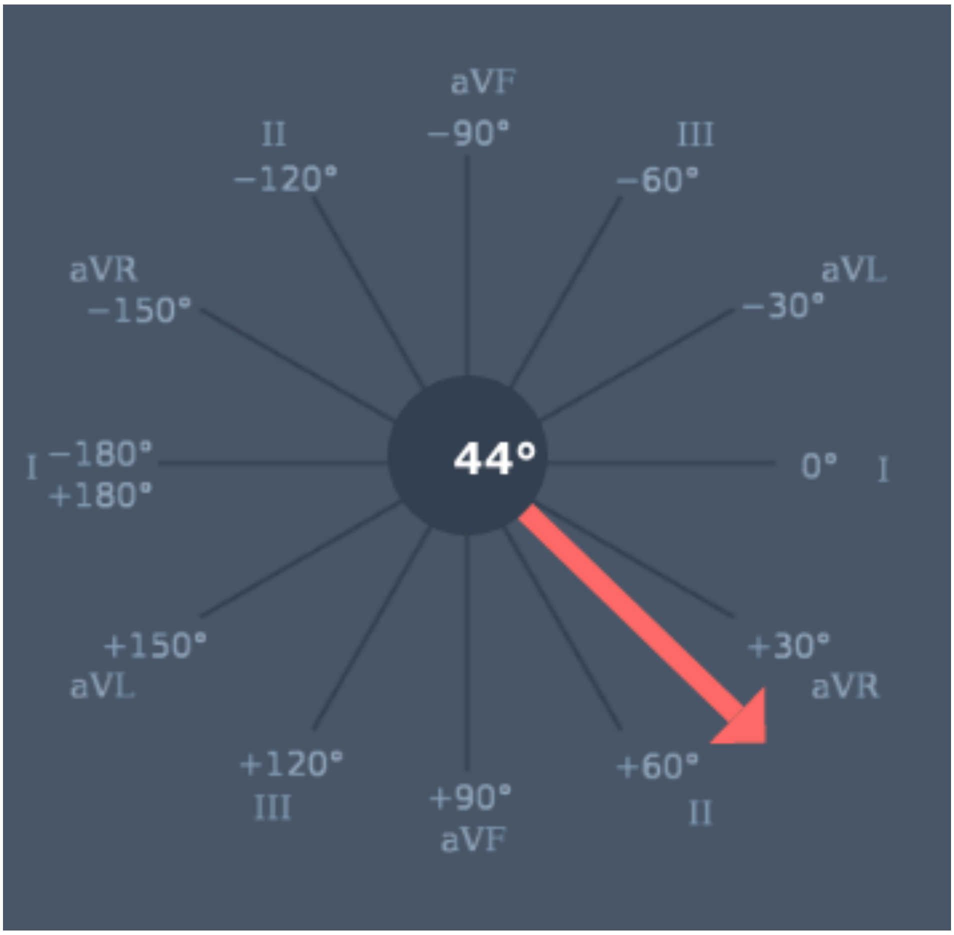

Figure 5.12. Example cardiac axis chart showing how an interpreter would select the cardiac axis they believe is present in the presenting ECG . To use this interactive chart an interpreter simply selects the arrowhead and drags it to the appropriate position on the chart, the degree marker at the centre updates with an interpreter's selection automatically

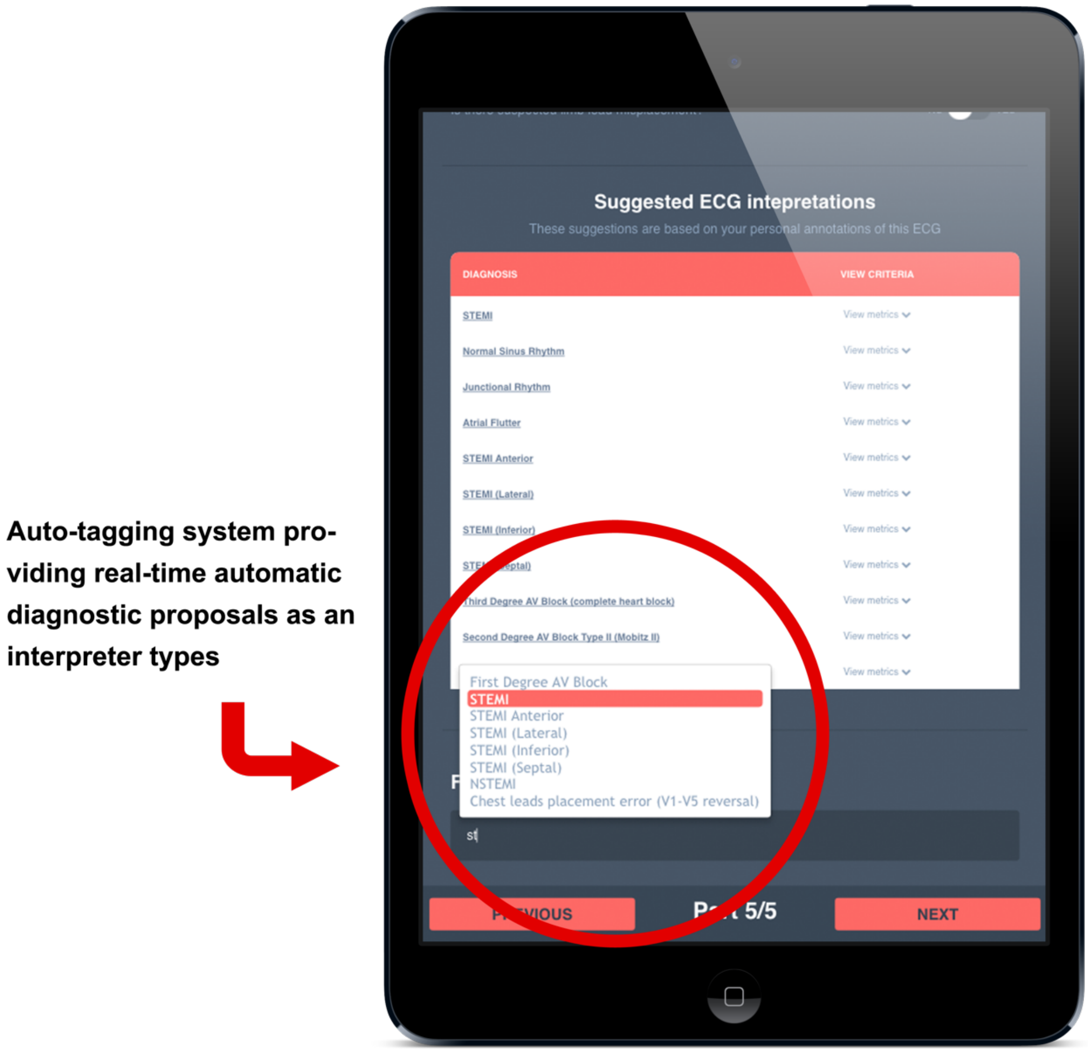

Figure 5.13a. Example auto-tagging tool illustrating how an interpreter be presented with an array of diagnostic proposals in real-time as they begin to type their interpretations

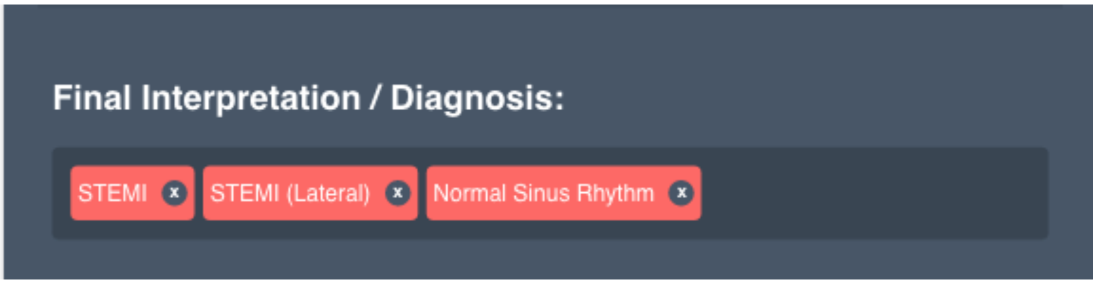

Figure 5.13b. Example of how the auto-tagging tool presents selected interpretations before an interpreter submits the final diagnoses

5.7. Conclusion

Through the use of clinical decision support tools, we foresee the potential to reduce inaccuracies and the oversight of co-abnormalities during ECG interpretation by using interactive touch-screen devices coupled with the IPI model and the DDA algorithm proposed in this chapter. By reducing cognitive workload, reducing a number of cognitive biases whist maintaining a structured interpretation process, we hypothesize that this model will lower the number of interpretation errors and increase diagnostic accuracy in ECG interpretation. This hypothesis forms the basis of future research outlined in Chapter 6.

Chapter 6:

An Evaluation of a Decision Support System and Rule-based Algorithm to Augment the Human Interpretation of the 12-lead Electrocardiogram

6.1 Introduction

Cardiac abnormalities are often manifested in the 12-lead Electrocardiogram (ECG) [3]. However, due to the complex nature of 12-lead ECG interpretation including analysis of multifarious leads, deflections and patterns, a considerable cognitive workload is forced on an interpreter [95]. This cognitive workload often contributes to inaccurate diagnoses, sometimes resulting from a Pavlovian response [293]. For example, diagnostic accuracy has been reported to be as low as 40% [8], [16], [17], [72], [92], [93], [179]. As previously highlighted, computerised diagnoses have been developed to act as an aid to human interpreters. However, this computerised analysis is firstly, often inaccurate, as machine algorithms often fail to recognise patterns in noisy ECG signals [19], [74], [169], [170]. Secondly, with common computerised analysis often only providing a single proposed diagnosis, cognitive biases can incur [18], [21]. Therefore, numerous studies have recommended computerised ECG interpretation should always incorporate clinical human decision making [12], [171]. Hence, Chapter 5 described an algorithm developed in this PhD to suggest potential diagnoses based on human driven annotations, whist aiming to evade a number of cognitive biases. Thus, we hypothesise that semi-automatic interpretation could be an optimal man-machine model for ECG interpretation. This hypothesis is based on the fact that the human cognitive memory prevails in pattern recognition (i.e. in noisy signals) enabling the interpreter to provide more accurate annotations whilst a machine performs better at using annotations to reason against a large set of rules (ECG criteria). Therefore, this chapter aims to test this hypothesis by comparing human interpretation of the 12-lead ECG, with computerised analysis resulting from human annotations.

6.2 Methodology

A differential diagnosis algorithm (DDA) has been integrated into the IPI system to provide multiple potential ECG diagnoses based on a human interpreter's ECG annotations (feature detection, waveform measurements and segment analysis). The number of suggestions generated by the DDA varies depending on human annotations. Pseudo code (Algorithm 5.1), an illustrative model (Figure 5.6a) and worked example

(Figure 5.6b) for the DDA can be seen in Chapter 5. The system can be viewed on any device with a web browser due to its platform independent responsive design as seen in Figure 6.1.

Figure 6.1. Presentation of the IPI+DDA system on mobile devices. An example of generated suggestion displays, questions and prompts.

The algorithm was implemented using web technologies including JavaScript, PHP, HTML and CSS. To store diagnostic criteria, the system uses the device agnostic data model and storage format known as JavaScript Object Notation (JSON) for defining the rules. These rules are then queried using the decision support algorithm programmed in JavaScript.

6.3 Study design

A counterbalanced study design was used to compare the diagnostic accuracies achieved when interpreters use the IPI+DDA system in comparison to the conventional approach to reading ECGs (i.e. all 12 leads presented in the commonly accepted 3x4+1R format). Therein, each interpreter interpreted five ECGs using the conventional method and five ECGs using the IPI method. The entire cohort was split into two subgroups referred to as A and B. Group A interpreted ECG numbers 1-5 using the conventional method and ECGs numbered 6-10 using the IPI+DDA method. Conversely, group B interpreted ECGs 1-5 using the IPI+DDA method, and ECG 6-10 using the conventional method. The counterbalanced study model is illustrated in Figure 6.2. All interpreters were asked to provide a self-assessed confidence rating for each interpretation. (scale 1-10, where 10 =very confident).

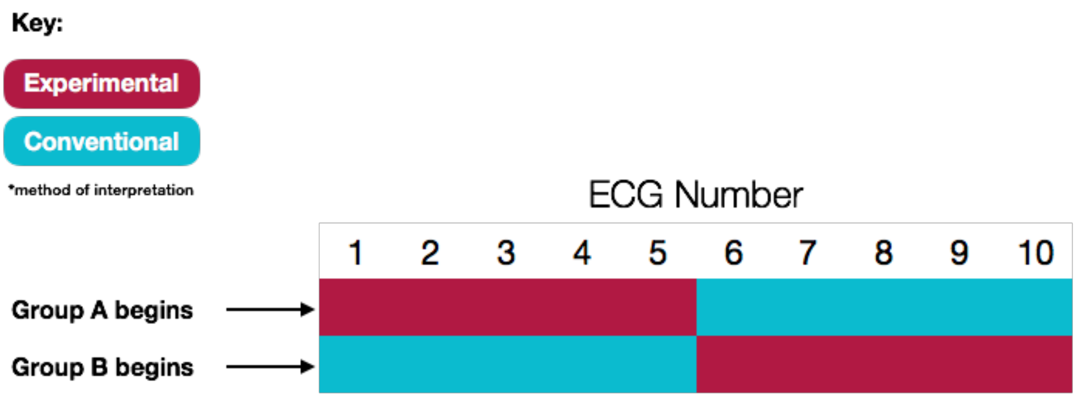

Figure 6.2. Counterbalanced model for interpreters using both the IPI+DDA method of interpretation and the conventional method of interpretation

All ten chosen ECGs originated from a publically available ECG repository with predefined pathologies and interpretation difficulty rankings [271] and were selected to align with the UKs National Health Service (NHS) healthcare science practitioner training programme [294] and to express the European Society of Cardiology (ESC) Core Curriculum for the General Cardiologist [269]. Seven of the ten ECGs exhibit cardiac pathologies (e.g. STEMI) whilst the remaining three ECGs exhibit anomalies (e.g. lead misplacement or dextrocardia). The selected ECGs used in this study are identical to ECGs selected for the IPI study and are used in the same order. A description of these ECGs can be seen in Figure 4.1.

6.3.1 Recruitment

Following authorisation from the Ulster University Faculty of Computing, Engineering and the Built Environment Research Governance Filter Committee, recruitment was undertaken via convenience sampling from four available participant cohorts; 1) International Society for Computerized Electrocardiology (ISCE) delegates, 2) junior doctors in two Scottish NHS trusts, 3) clinical physiology students and 4) European Society of Cardiology members (ESC). Participation was undertaken in both a classroom environment and remotely via website hyperlinks. As the system was developed responsively using web technologies, it is device and platform agnostic and can be accessed on any device with an internet connection. The participants in this cohort are independent from the participants in the IPI study illustrated in chapter 4 and chapter 5.

6.3.2 Data collection

Before beginning, interpreter demographics were collected using an online form. These include; age, gender, occupation, years of experience interpreting ECGs and number of ECGs interpreted annually. Interpreters were also required to give informed consent before proceeding to interpret all 10 ECGs. All annotations are collected and saved via an AJAX function in a MySQL database on an Apache web server.. Of which, 35 participant completed ECG interpretations using both approaches, whilst 14 participants did not complete interpretations using both approaches but their completed interpretations were recorded. This resulted in 280 interpretations from 35 participants (as some participants did not complete all ECGs), plus 70 interpretations from 14 participants who did not use both methods. Overall 375 interpretations were recorded (215 control interpretations, 160 IPI+DDA interpretations). Demographics are further presented in Tables 6.1 and 6.2.

Table 6.1. Subject profession profiles from participants.

Occupation	Count
Student	21
Cardiologist	4
Electrophysiologist	2
Junior doctor	4
Researcher	2
Consultant	1
Professor of Nursing	1
Total	35

Table 6.2. Demographics of participants

Profile feature	Statistic
Age	Mode = <30 years old
Gender	17 Male / 18 Female
Experience	Mode = <10 years
ECGs interpreted annually	Mode = <100 ECGs

6.3.3 Data analysis

Data was analysed using the Structured Query Language, Microsoft Excel [272] and the R programming language [273]. A Shapiro–Wilk test was used to test for normality, data was found to be not normally distributed. A two-tailed Mann-Whitney U test was used to test for statistical significance between interpretation methods. To compare statistical significance between interpretation method proportions we conducted Chi-squared tests. The p-value used to determine statistical significance was ≤0.05.

6.4 Results

The percentage of correct interpretations for reading ECGs using the conventional approach was 42.61% (reflecting interpretation accuracy scores presented within literature), whilst interpretations using the IPI+DDA method was 51.35% (Chi-squared p-value = 0.1852). Thus, interpretations resulting from use of the IPI+DDA were 8.7% more accurate. Five out of seven ECGs were interpreted more accurately using the IPI method as illustrated in Figure 6.3. The IPI method did not improve the detection of ECGs which had been recorded where there was lead misplacement or dextrocardia despite the IPI+DDA interface directly prompting users to carry out an inspection for lead misplacement. This further highlights the problems of electrode misplacement. Overall self-rated confidence in ECG interpretation using the control method was 5.37/10 (SD=2.95) whilst the IPI method was 5.58/10 (SD=3.02). This indicates interpreters feel 3.9% (although not statistically significant, *Z*-Score = -0.7, p-value = 0.48) more confident in interpreting ECGs using the IPI method. The average duration of interpretations using the conventional method was 108.55 seconds (SD=32.57) and 629.94 seconds (SD=266.98) when using the IPI method. Thus, the average IPI method duration was 6.19 times longer. However, the 6-fold increase in interpretation time is confounded by participants being unfamiliar users of the system. This is highlighted in further interpretation of the time analysis. As users become more familiar with the system, the interpretation time decreases (mean time shortening = 130.25s).

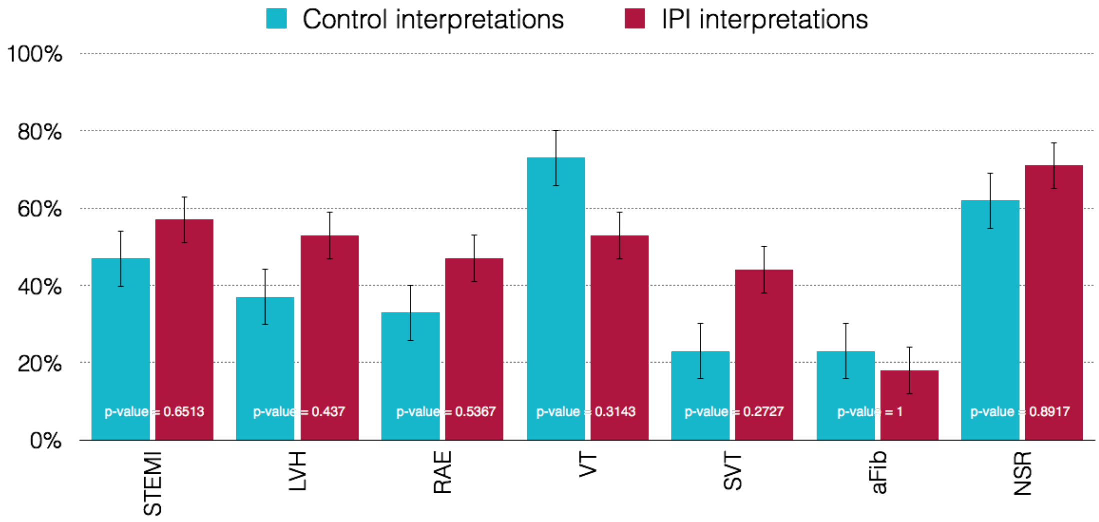

Figure 6.3: ECG interpretation accuracy in both cohorts for ECGs with a pathology

6.4.1 Correct suggestion ranks of the decision support algorithm

Due to the DDA design, there is a variable number of suggestions listed based on interpreter input. However, we found that between three and six suggestions were most frequently presented (44% of all interpretations). The mode rank of the correct suggestion in the list was three (mean=3.63, SD=3.01). The correct suggestion appeared within the first three suggestions in 60.29% of interpretations (refer to Table 6.1 and Figure 6.4).

Table 6.1. Table illustrating the number of diagnostic suggestions from the IPI+DDA, number of correct algorithm diagnoses, number of instances (i.e. the number of times the relative number of suggestions was generated), and the percentage of instances containing the correct suggestion.

Number of diagnostic suggestions from the IPI +DDA	**Number of instances**	**Number of instances that contain a correct diagnostic suggestion**	**Percentage of correct algorithm diagnosis (%)**
1	6	0	0
2	8	5	62.5
3	15	4	26.7
4	21	3	14.3
5	18	5	27.8
6	14	4	28.6
7	10	5	50
8	8	5	62.5
9	12	9	75
10	8	1	12.5
11	11	6	54.6
12	8	6	75

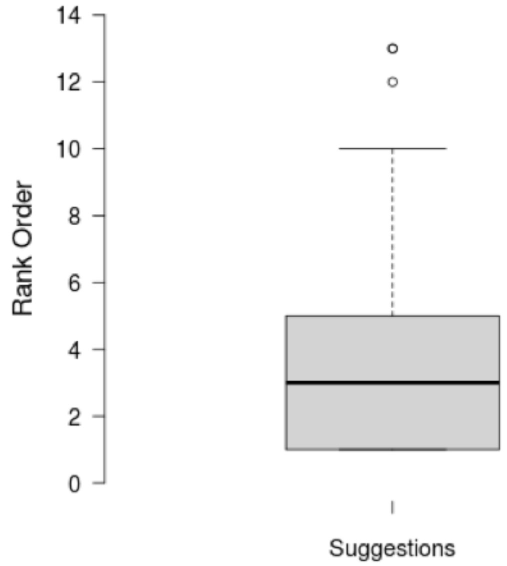

Figure 6.4. Box plot illustrating the range and median of the correct diagnosis rank order in the list of suggestions generated by the DDA.

6.4.2 Algorithm accuracy vs. number of suggestions

We found that when two suggestions are presented, there is a 62.5% likelihood the right suggestion will be in the list. We also found that when nine suggestions are generated there is a 75% likelihood of the correct suggestion appearing in the list. However, presenting nine suggested diagnoses to an interpreter could potentially lead to a number of concerns, including; a reduction in trust of the system's ability to provide accurate diagnoses, overwhelming the interpreter with too much information and thereby increasing cognitive load which we are aiming to reduce. However, not all generated suggestions need to be presented to an interpreter. In this study, we present suggestions which the algorithm assesses annotations to be >50% similar to diagnostic criteria. This occasionally presents large numbers of interpretations. In future iterations, a more sophisticated method of selecting the number of suggestions to be presented could be used (i.e. consider sensitivity and specificity). Illustrated in Figure 6.5.

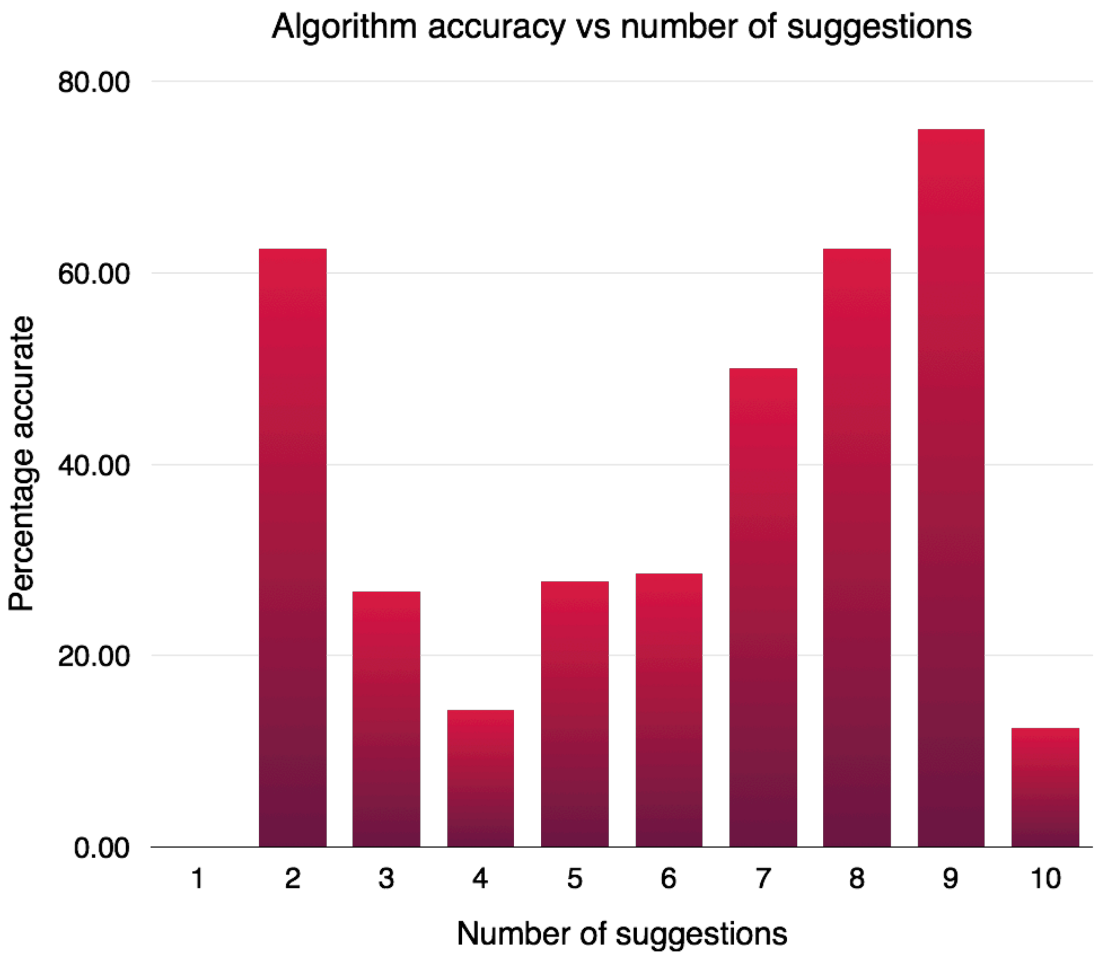

Figure 6.5: Graph presenting ECG suggestion algorithm accuracy vs the number of suggestions generated for each interpretation

As evident in Figure 6.5, the graph illustrates a 'dip' in the percentage accuracy when 3-6 suggestions are generated. This could be a result of a number of constraints within the study. These include;

1) coincidental erroneous cohort annotations resulting in inaccurate suggestions. The study could be expanded to perceive of this cohort was at fault.

2) each pathology has a set of attributing diagnostic criteria. However, occasionally a single diagnostic criterion within the set of diagnostic criteria is more significant in the diagnosis of a pathology. To take this into consideration a weighting mechanism could be implemented for each criterion, however this data is often subjective, varying and not recorded quantitatively in literature

3) when interpreters annotate specifically (when care is given to imputation and are accurate) only one or two suggestions are made. However, when annotations are less specific, erroneous, or are confounding more suggestions are generated. This may result in the number of suggestions between 3-6 preforming less accurate suggestion diagnoses. Finally, when 7-9 suggestions are generated there is a greater likelihood an applicable suggestion is presented within the generated list due to a larger presentation of suggestions.

6.4.3 Human accuracy vs. number of suggestions

When comparing human interpretation accuracy with varying number of suggestions generated by the DDA, we found that the human interpreter will provide the correct interpretation 70% of the time when seven suggestions are presented. When two, three, five or six suggestions are generated, the human interpreter is more than 45% likely to interpret the ECG with a correct answer. This percentage is greater than the percentage of correct human interpretations when using the conventional method of ECG interpretation. As one of the aims of this study is to reduce the cognitive load forced upon an interpreter, it is imperative additional information does not also contribute to the original cognitive burden but conversely assists the interpreter in their decision making process. Therefore, a limited number of suggestions must be made to an interpreter. More details are reported in Table 6.2 and presenting in Figure 6.6.

Table 6.2. Table illustrating the number of suggestions compared to the number of correct human interpretations, the number of suggestion instances (i.e. the number of times the relative number of suggestions was generated), and the relative human accuracy as a percentage.

Number of diagnostic suggestions from the IPI +DDA	**Number of instances**	**Number of instances that contain a correct human interpretation suggestion**	**Percentage of human Accuracy (%)**
1	6	1	16.7
2	8	4	50
3	15	7	46.7
4	21	6	28.6
5	18	9	50
6	14	9	64.3
7	10	7	70
8	8	2	25
9	12	4	33.3
10	8	1	12.5
11	11	5	45.5
12	8	3	37.5

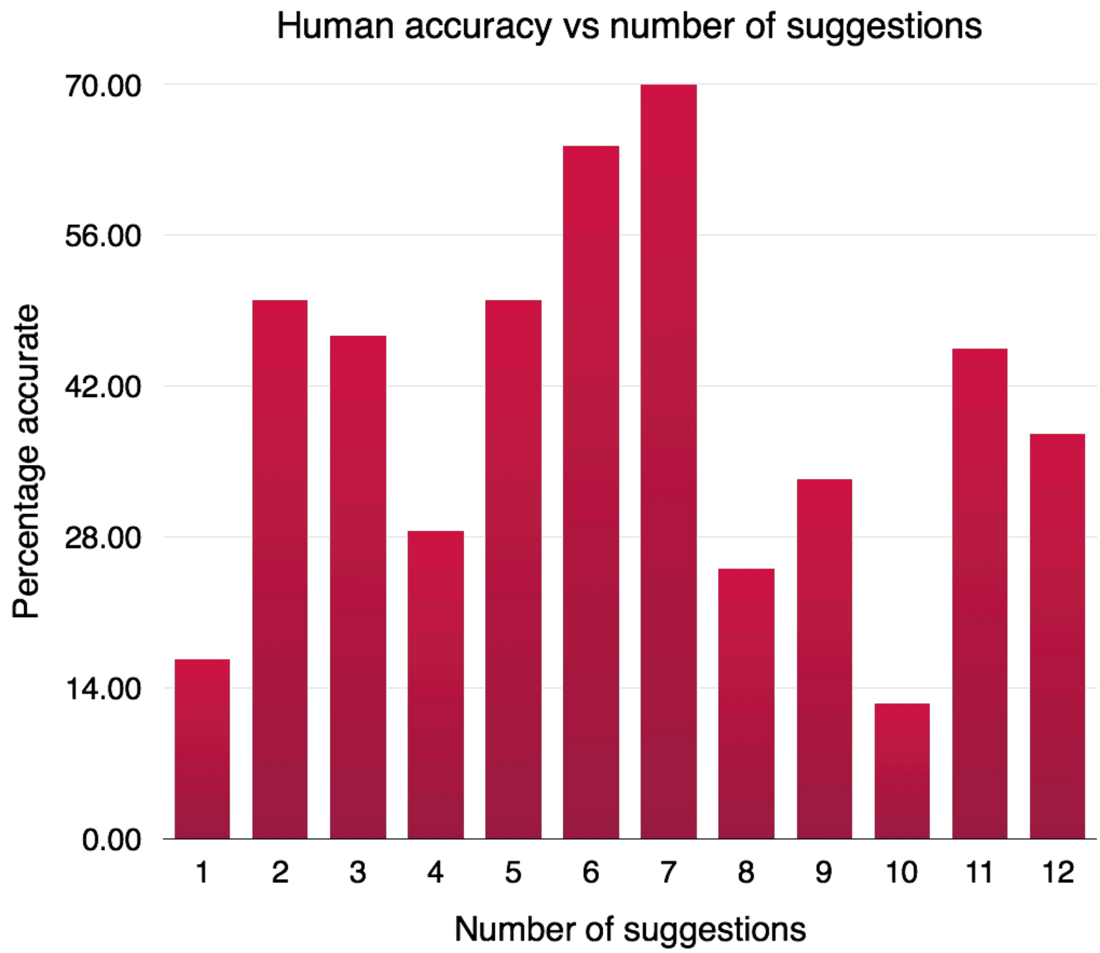

Figure 6.6: Graph presenting ECG human interpretation accuracy vs the number of suggestions generated for each interpretation

6.4.4 Algorithm accuracy vs. human accuracy

When comparing algorithm suggestions directly with the human interpretations for each ECG we find in 7/10 cases the DDA algorithm provided more correct interpretations than the human interpreter (varying statistical significance, refer to Table 6.3 and Figure 6.7). However, human interpretation was more accurate when reading ECGs exhibiting Left Ventricular Hypertrophy (LVH), Ventricular Tachycardia (VT) and Supraventricular Tachycardia (SVT). In the case of LVH, one possible reason for this is that the system does not require input for QRS amplitude. Therefore, the criteria for LVH is incomplete resulting in the algorithm being unable to process relevant data to generate an accurate suggestion. Similar, assumptions can be made in the cases of VT and SVT.

Table 6.3. Table illustrating the percentage difference in accuracy between the IPI+DDA method and the and the human interpreter in ECG interpretation. Positive inflection illustrates the algorithm is more accurate, conversely a negative inflection illustrates human interpretation was more accurate.

ECG number	Percentage difference in accuracy between DDA and the human interpreter (positive = algorithm more accurate, negative = human more accurate)	Test of Equal or Given Proportions (Chi-squared)
STEMI	10.53	p-value = 0.7271
LVH	-37.50	p-value = 0.06789
RAE	31.25	p-value = 0.1365
VT	-28.57	p-value = 0.2519
SVT	-50.00	p-value = 0.009598
Atrial fibrillation	5.88	p-value = 1
Limb lead misplacement	22.22	p-value = 0.2291
Dextrocardia	25.00	p-value = 0.1742
Chest lead misplacement	26.67	p-value = 0.1709
Normal sinus rhythm	28.57	p-value = 0.1052

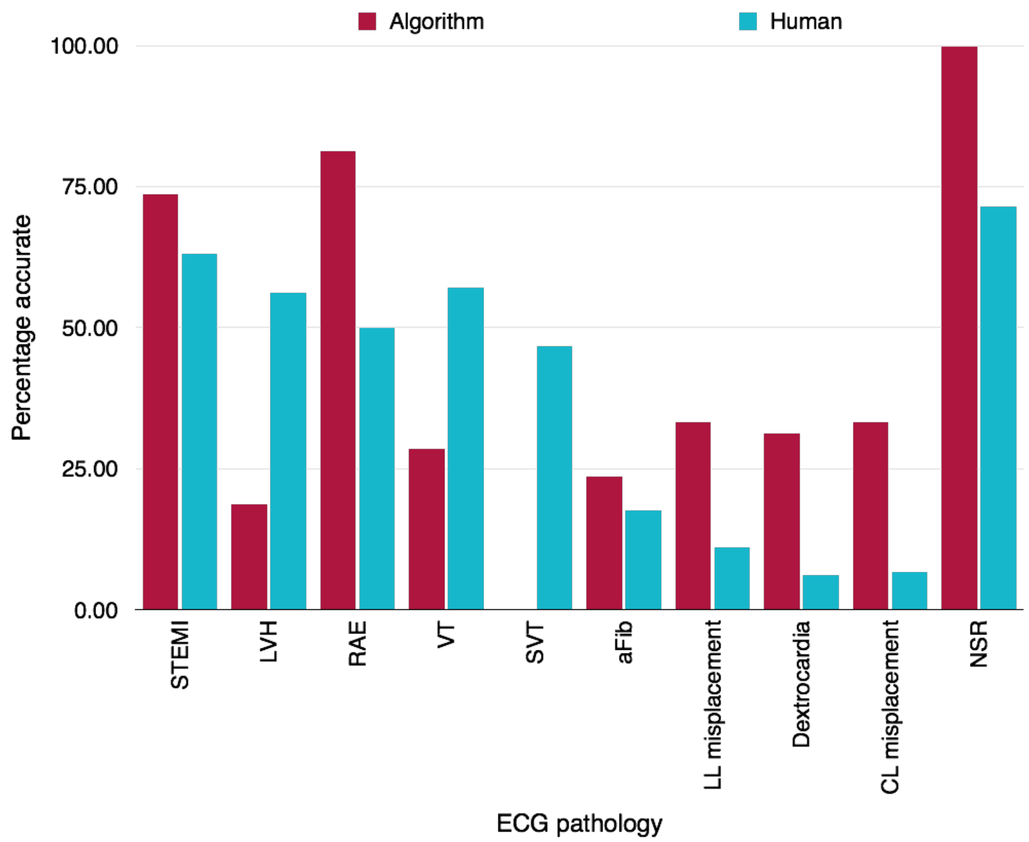

Figure 6.7: Graph presenting an accuracy comparison between the ECG suggestion algorithm and the human interpreter in ECG interpretation

6.4.5 Interpretation duration

Interpretation using the IPI+DDA method took 6.19 times longer to analyse the same ECG. ECGs presenting with right-arm left-arm lead reversal, Atrial Fibrillation and STEMI required most time for interpreters to interpret. However, STEMI was the first ECG encounter, therefore a 'newness' effect must be taken into consideration. ECGS presenting with chest lead misplacement and normal sinus rhythm required least time to interpret on average. On average, normal sinus rhythm required nearly five times less interpretation time than right-arm left-arm lead reversal. Table 6.4 and Figure 6.8. However, the 6-fold increase in interpretation time is confounded by participants being unfamiliar users of the system. This is highlighted in further interpretation of the time analysis. As users become more familiar with the system, the interpretation time decreases (mean time shortening = 130.25s). This can be attributed to a 'Learning Effect'.

Table 6.4: Table presenting average ECG interpretation durations

ECG ID	Average time
1	922.64
2	588.97
3	721.85
4	637.78
5	555.24
6	897.46
7	1006.24
8	494.28
9	252.04
10	222.87

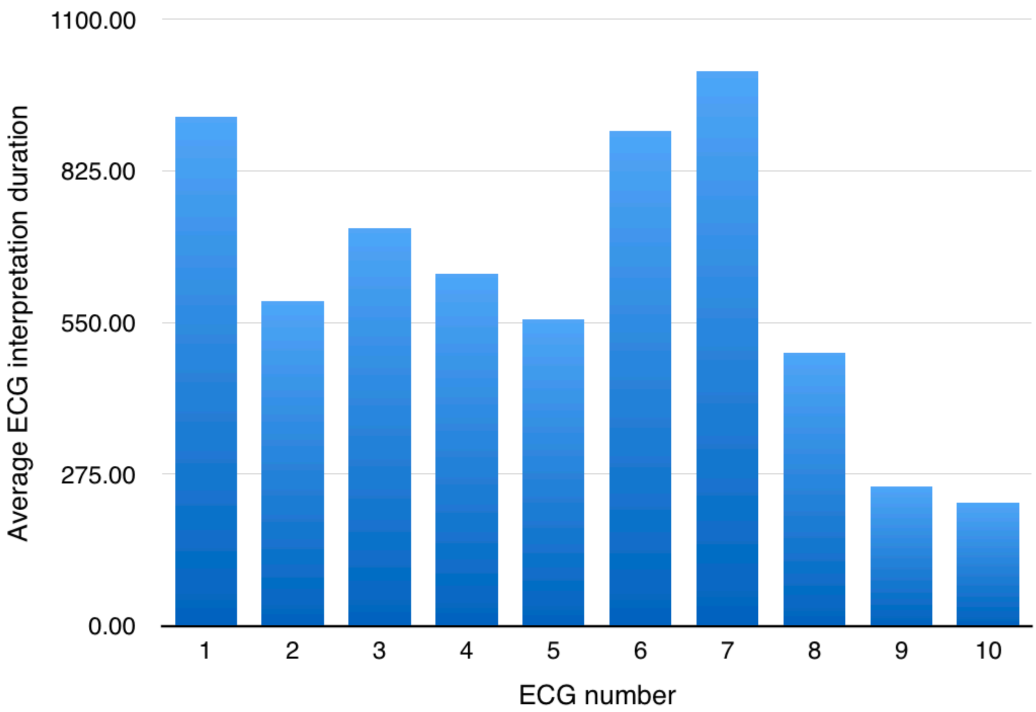

Figure 6.8: Graph presenting average ECG interpretation durations

When conducting segment analysis, it was discovered on average segment one required most time to interpret (185s). However, this could be a result of the 'newness' effect. On average segment four required 132s to interpret, requiring the second longest interpretation time. This segment required analysis of the QRS morphology, including time intensive interval measurements. Table 6.5 and Figure 6.9

Table 6.5: Table presenting average ECG segment interpretation durations

ECG	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
1	112.25	118.17	191.88	238.17	262.16
2	83.84	103.14	114.01	181.64	106.35
3	225.67	110.86	111.65	210.33	63.34
4	340.60	36.48	99.03	101.56	60.11
5	434.95	59.24	47.58	95.31	56.74
6	378.12	36.38	148.78	173.42	160.76
7	69.38	118.25	115.87	127.41	91.79
8	103.06	150.32	68.06	89.02	83.83
9	50.94	59.78	31.79	54.42	55.11
10	51.15	52.67	37.40	52.88	28.78
Average	185.00	84.53	96.60	132.42	96.90

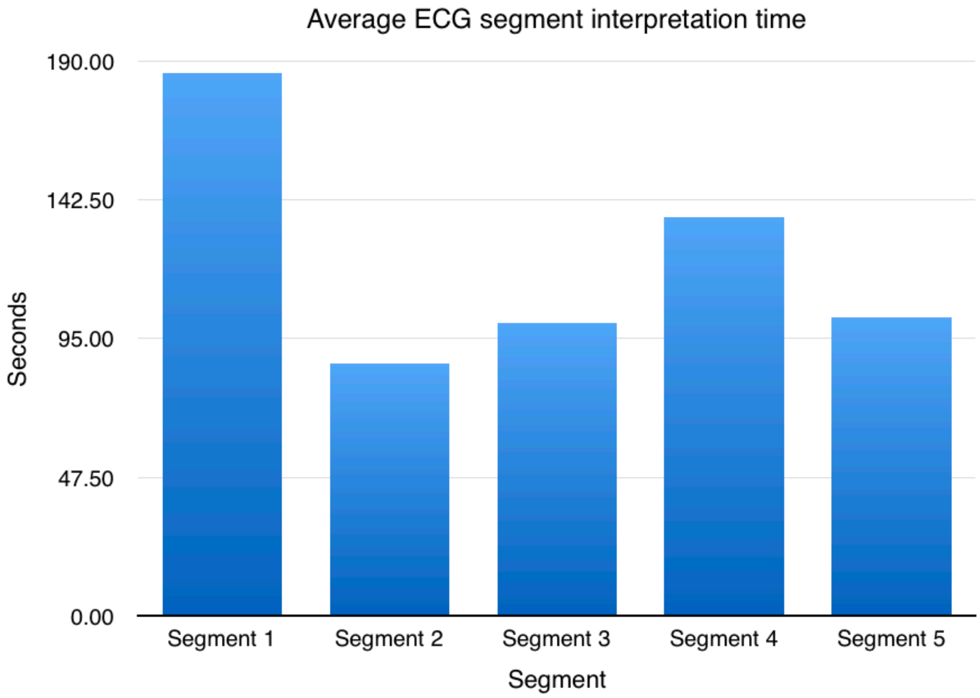

Figure 6.9: Graph presenting average ECG segment interpretation durations

6.5 Discussion

There is potential to improve the accuracy of ECG interpretation by using an interactive decision support system to augment the human interpretation process. We found the IPI+DDA system increased the number of correct interpretations by 8.7% and improved interpreter self-rated interpretation confidence by 3.9% (although results were not statistically significant). The IPI+DDA method did not improve the detection of ECGs which had been recorded where there was lead misplacement or dextrocardia despite the IPI+DDA interface directly prompting users to carry out an inspection for lead misplacement. This further highlights the problems of electrode misplacement within ECG interpretation.

The average IPI+DDA method duration was 6.19 times longer than the conventional method of ECG interpretation. However, a learning effect was discovered with a mean time shortening of 130.25s as interpreters iterated through the series of ECGs. ECGs presenting with right-arm left-arm reversal required most time to interpret, whilst normal sinus rhythm, required the shortest interpretation duration. It was also discovered the QRS morphology required most time to interpret (with the exception of p-wave morphology assessment being excluded due to the newness effect).

In 70% of cases the IPI+DDA algorithm suggested the correct interpretation more often than the human interpreter. With the ability to augment the interpretation process with potential diagnoses, we identified that displaying as many as seven computerised diagnoses improves human diagnostic accuracy in ECG interpretation.
Numerous adaptations could be made to the enhance this system. Refinements could be made to the diagnostic criteria stored in the JSON object, for example, adding further specific criteria to help diagnose LVH, VT and SVT. A second enhancement could be to define and implement weightings to correspond with the importance of each diagnostic criterion in the JSON object allowing the DDA algorithm to improve how it rank its suggestions. Thirdly, some annotations could be pre-calculated by accurate computerised analysis, this could decrease interpretation time and increase diagnostic accuracy. One further enhancement could be to create an interface to allow clinicians to edit/update diagnostic criteria following a verification process.

6.6 Conclusion

A semi-automatic algorithm has been developed to suggest potential diagnoses based on human interpretation annotations. Hence, this chapter presents an evaluation of the previously demonstrated IPI model (Chapter 3 and 4), augmented with a differential diagnoses algorithm demonstrated in Chapter 5. Although results were not statistically significant, we found; 1) our decision support system increased the number of correct interpretations, 2) the DDA algorithm suggested the correct interpretation more often than humans, and 3) as many as 7 computerised diagnostic suggestions augmented human decision making in ECG interpretation. Statistical significance may be reached by expanding the sample size. Therefore, with future of ECG interpretation likely to be paperless, there is an opportunity to improve ECG interpretation accuracy in clinical practice using an interactive decision support system such as this.

In Chapter 7 we discuss a potential pathway to practice for an interactive model such as the described in Chapters 3, 4, 5and 6. We also consider the transferability of these thesis concepts into other medical domains, their application and use.

Chapter 7:
Discussions, prospective studies and Conclusion

7.1 Discussion and summary of contributions

The domain of medical informatics is understood to be the application of computing and informatics in medicine. Considering the nature of this domain, and the collection of work professed throughout this thesis, it is therefore apparent the primary contribution to knowledge within this thesis falls within the field of medical informatics. Specifically, both the IPI study, discussed in Chapters 3 and 4, and the IPI+DDA study, discussed in Chapters 5 and 6, have generated knowledge in the subdomains of cognitive engineering and computerised decision support within computerised electrocardiology. This is evidenced in manifestation of a novel, digital interpretation system which guides the interpreter though a typical 12-lead ECG reporting process. Furthermore, a computerised decision support algorithm has been created to augment the decision-making process. These two contributions to knowledge have been discussed in Chapter 3, 4, 5 and 6 within this thesis and have been summarised below.

7.1.1 IPI

We believe this thesis is the first research in this domain to assess whether the diagnostic accuracy of 12-lead ECG interpretation can be improved by utilising modern web technologies to structure the interpretation process. To achieve this, an interactive web-based system was developed which exploit opportunities created by interactive touch screen devices. By interpreting a 12-lead ECG digitally, the opportunity to deconstruct a complicated task into manageable exercises has become possible.

We believe that interpreters should always follow up with sequential system of interpretation - even in ‘straightforward’ cases. Furthermore, this research led to the suggestion that distinct steps within the interpretation process should be clearly categorised, and serve as checklist to facilitate the eradication of missed co-abnormalities during ECG interpretation. Moreover, by managing an interpreters cognitive load, we found a reduction in interpretation errors and an improved diagnostic accuracy in 12-lead ECG interpretation. A large variability in ECG reporting terminology was also discovered and documented. We believe a system such as this could be used as a rigorous ECG reporting protocol within a teaching or training environment, or within the precise conditions required within ECG core lab reporting.

Through reviewing the key points within this research, we discover a series of contributions have been made to the field of medical informatics, specifically cognitive engineering and computerised decision support within computerised electrocardiology. All contributions to knowledge have been itemised within Chapter 1.

7.1.2 IPI+DDA

We believe this thesis is the first research in this domain to assess whether the diagnostic accuracy of 12-lead ECG interpretation can be further improved by utilising modern web technologies to both structure the interpretation process and generate suggested diagnoses based on an interpreter's annotations. Furthermore, the aforementioned system exploits the opportunities created by interactive touch screen devices. Within which, a semi-automatic differential diagnoses algorithm has been implemented to collect, interpret and compare human annotations with recognised diagnostic criteria, finally presenting potential diagnoses to an interpreter for consideration.

Through this portion of our research we discovered that by incorporating the aforementioned algorithm the number of correct interpretations increased, interpreter self-rated confidence increased and in 70% of cases - the algorithm suggested the correct interpretation more often than the human interpreter. Furthermore, we have identified that displaying up to seven potential diagnoses for an interpreter to consider can improve diagnostic accuracy.

Therefore, by reviewing our research, we discover the interpretation of the 12-lead ECG has been augmented. Consequently, we determine a series of contributions has been achieved within the field of medical informatics, specifically cognitive engineering and computerised decision support within computerised electrocardiology. All contributions to knowledge have been itemised within Chapter 1.

7.1.3 Recommendations

One of the most prominent limitations of this research is the time required to interpret an ECG. This extension of interpretation duration is likely to be too time intensive in a clinical diagnosis scenario, despite enhanced accuracy. Nevertheless, the ability to increase interpreter diagnostic accuracy in ECG interpretation could allow the IPI system to be used in other capacities. Such a system can be used as; 1) a rigorous ECG reporting protocol. As this system encourages an interpreter to at least view each of the recognised ECG reporting components it reinforces the reporting protocol interpreters should be using in daily practice 2) a teaching or training tool. As the model breaks the cognitive heavy task of interpreting an ECG into its individual components and further into subcomponents (including interval measurements and morphology assessment) it illustrates a 'best practice' methodology which can be used to analyse 12-lead ECGs presenting all variations of pathology. This could encourage users to practice an appropriate methodology. As ECG interpretation is memory intensive this model could also be used as an interpretation guide in the early stages of learning. This was frequently reflected in participant feedback. 3) for use in an ECG core lab requiring precise manual interpretation 4) assessment of clinical competence. As the system requires manual annotation throughout the interpretation process – which can be compared against diagnostic criteria – the system to be used as an automatic cross-examination tool to assess a clinicians ability to assess an ECG.

Furthermore, it is recommended that interpreters adopt a sequential system for the interpretation of ECGs – even cases exhibiting 'obvious' symptoms. Thus, categorisation of distinct steps within the interpretation procedure serves as a checklist to facilitate the eradication of missed co-abnormalities during ECG interpretation.

7.2 Transferability of thesis concepts

Within this thesis, we have discussed how CDSSs can be used to assist in the detection of cardiac abnormalities. Nevertheless, for a CDSS to be used it must be made available and fit into a practitioners/student's routine practices as seamlessly as possible. Therefore, in this chapter we discuss industry relationships which aim to create a potential pathway to practice for the IPI and/or IPI+DDA systems. Furthermore, within this chapter we also discuss the transferability of thesis concepts into other domains, and potential limitations of this research.

7.2.1 Realising the IPI model; Potential pathway to practice

7.2.1.1 Introduction

With the prevalence of CVD, contributing to 29% of worldwide fatalities, it is imperative to optimise its early detection. The 12-lead ECG has been the primary method of assessing the cardiac state of a patient for more than 70 years. By the early 1960s, computer decision support began to be introduced to augment human interpretation [162], [163]. As time progressed, algorithms became more sophisticated [167] and commercially available [164]–[166]. However, this thesis focusses on augmenting ECG reading using interactive user interfaces in order to provide decision support.

Typically, a 12-lead ECG is presented in a 3x4+1R grid format with each cell representing one of the 12 leads and an extended rhythm strip added below (+1R) [59]. This format, is known to deliver significant cognitive load, and thereby deplete the cognitive performance of an interpreter [95]. To ameliorate cognitive workload, CDSS often aim to reduce the cognitive workload forced upon the interpreter [168]. To achieve this, some institutions often use checklists for ECG reporting [4], [17], [37], [69]–[72]. Although some components vary, a typical reporting procedure would include the following steps; 1) heart rate, 2) rhythm analysis, 3) cardiac axis, 4) conduction times, 5) morphological features, and 6) final diagnoses. Other facilities have conducted research using a series of questions and prompts to guide the user though the interpretive process [23], [295]. This research also aimed to reduce the cognitive load by segmenting the 12-lead ECG into the five previously mentioned reporting components. Further motivations for this research include developing preventative measures to reduce the likelihood of ‘early satisfaction syndrome’ [8],[9], in which interpreters come to a conclusion prematurely. A model was created and named “Interactive Progressive based Interpretation” (IPI). The procedural sequence can be seen in Figure 7.1.

Results from this study indicate an increase in final interpretation accuracy can be achieved through using interactive touch screen devices to manage cognitive load alongside prompts to guide an interpretation process. Hence, a recommendation was suggested to incorporate a set of distinct procedural steps within the interpretation process, serving as a ‘checklist’ to eradicate missed co-abnormalities [23].

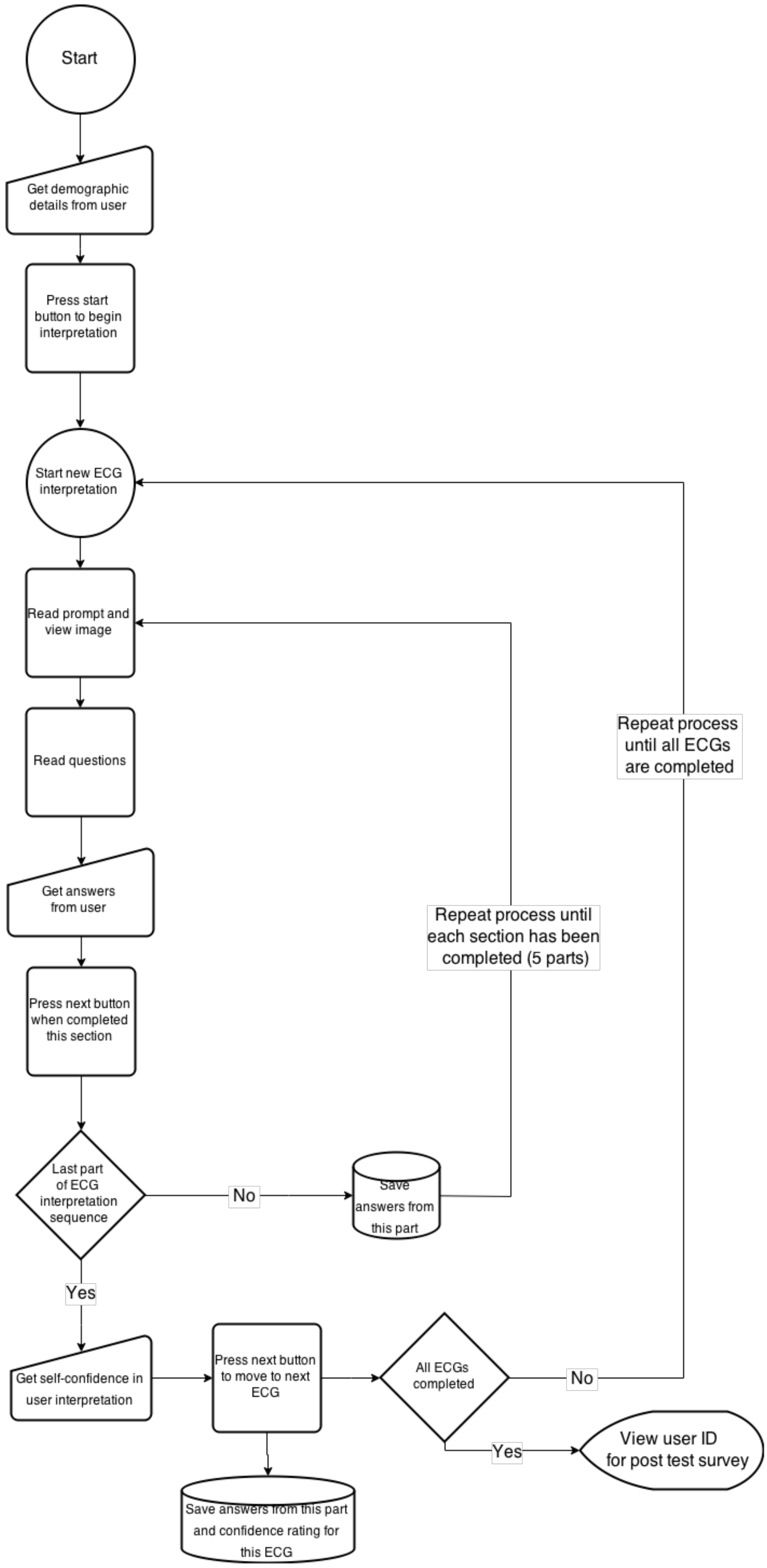

Figure 7.1. Procedural sequence for interpreters using the IPI model and system to interpret a 12-lead ECG.

7.2.1.2 Methods

Although a CDSS which manages an interpreters cognitive load has potential to improve diagnostic accuracy a pathway to practice needs to be established enabling a clinician/researcher to efficiently use the software. Typically, a 12-lead ECG is stored in Portable Document format (PDF) or in raw data within XML, SCP-ECG, DICOM, HL7-aECG, ecgML, Philips XML, mECGml, MFER or XML-ECG [296]. As a company, AMPS-LLC aim to create a paradigm which stores ECG data inside the commonly used PDF format [232]–[234], [297]. To achieve this, AMPS-LLC extracts ECG recording data (often stored within an Extensible Markup Language (XML) file), including; demographics, measures, interpretations, and morphologies among others. This data then populates a proprietary AMPS data structure. Once this is populated, it is restructured into desired proprietary formats for use within the healthcare system (XML, DIACOM/MORTARA etc.). This is then embedded within a generated PDF. AMPS-LLC also provides the opportunity to output other graphical formats including PNGs or JPGs. Due to the data acquisition and structural method each lead is stored individually within a data framework. Therefore, potential to generate a segmented ECG for use within the IPI system became apparent. By partnering with AMPS-LLC a platform was created to upload an ECG recording data file (XML), a response was generated which produced multiple segmented ECG images, and hosted them in the cloud (Microsoft Azure server). These images would then be placed within the IPI model, available for user interaction. This enables users (clinicians, researchers or others) to upload ECG data stored within healthcare repositories and automatically be presented with an interactive CDSS to aid the clinical decision making process. A figure for this pathway can be seen in Figure 7.2.

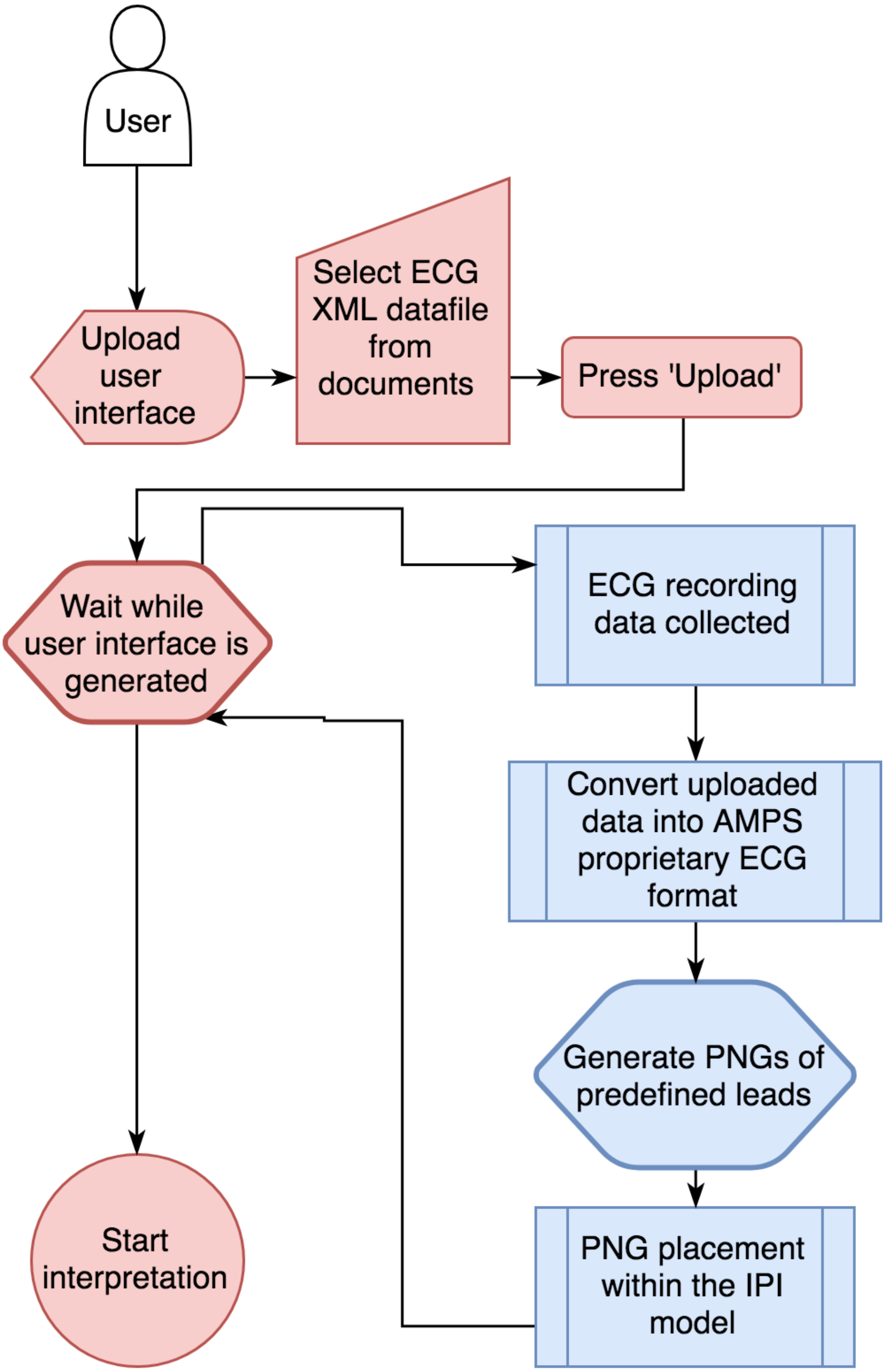

Figure 7.2. User flow and image generation procedure for IPI model to be used alongside AMPS-LLC conversion tools to create a pathway with practice for ECG interpretation.

7.2.1.3 Model implementation

To allow the system to be used ubiquitously it has been developed using web-based technologies and hosted on the university server. The webpage structure was created and implemented using Hypertext Mark-up Language version 5 (HTML5). Cascading Style Sheets (CSS3) were used to create a consistent, user, friendly, and responsive user experience for interpreters. The scripting language, JavaScript, was used, alongside the JQuery library, was used to create an interactive experience by implementing responsive animations and collection of data through text/button/radio/checkbox/slider field entry. Finally, the Hypertext Pre-processing language (PHP) recorded data entry values to a MySQL database. Data was sent to the server via Asynchronous JavaScript and XML (AJAX).

AMPS software is implemented using C++ and hosted on a Microsoft Azure web server. The connection between this webserver and the front-end user interface was controlled asynchronously via AJAX. This enabled calls to request a PDF conversion, retrieve a JSON (JavaScript Object Notation) response with an embedded link to a series of PNGs hosted on the Azure webserver.

7.2.1.4 Conclusion

An interactive model has been developed to reduce cognitive workload forced upon interpreters of 12-lead ECGs. A potential ‘pathway to practice’ has now been created facilitating interpreters the opportunity to upload raw ECG files (XML) and have a bespoke user interface generated which integrates the uploaded ECG into the IPI model. We believe this example illustrates the potential to augment 12-lead ECG interpretation without needing to replace the conventional method.

7.2.2 A digital training platform for interpreting radiographic images of the chest

Many of the concepts discussed within this thesis are applicable to other areas of research within the medical domain. Once such field is radiology. Through collaboration opportunities with other academics at Ulster University a research study was composed to create a digital training platform to aid chest image interpretation. See Figures 7.5-7.9.

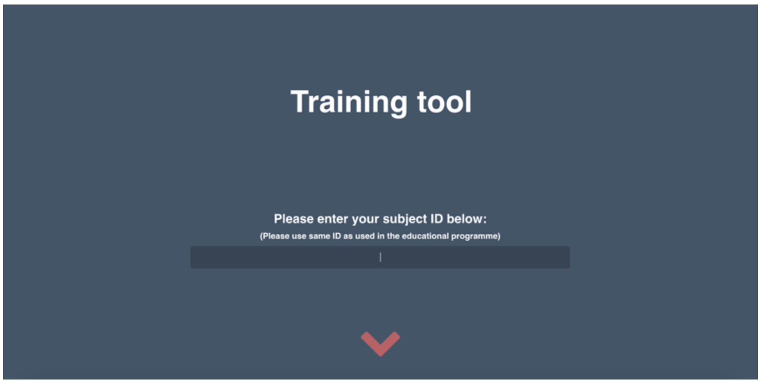

Figure 7.5. Training tool login screen for radiology chest image interpretation system. Users are expected to use the same login as they used when viewing training content.

This platform presented digital chest images to interpreters within a predefined search strategy. This strategy facilitated clear, structured, concise and methodical interpretation. The development of the search strategy followed a similar approach implemented with the IPI model whereby image interpretation was split into six components of interpretation, namely; (1) General image considerations, (2) Tubes/lines/devices, (3) Bony thorax, soft tissues, (4) Diaphragm/heart/mediastinum, (5) Lung zones, (6) Lung shadows. This can be seen in Figure 7.6a.

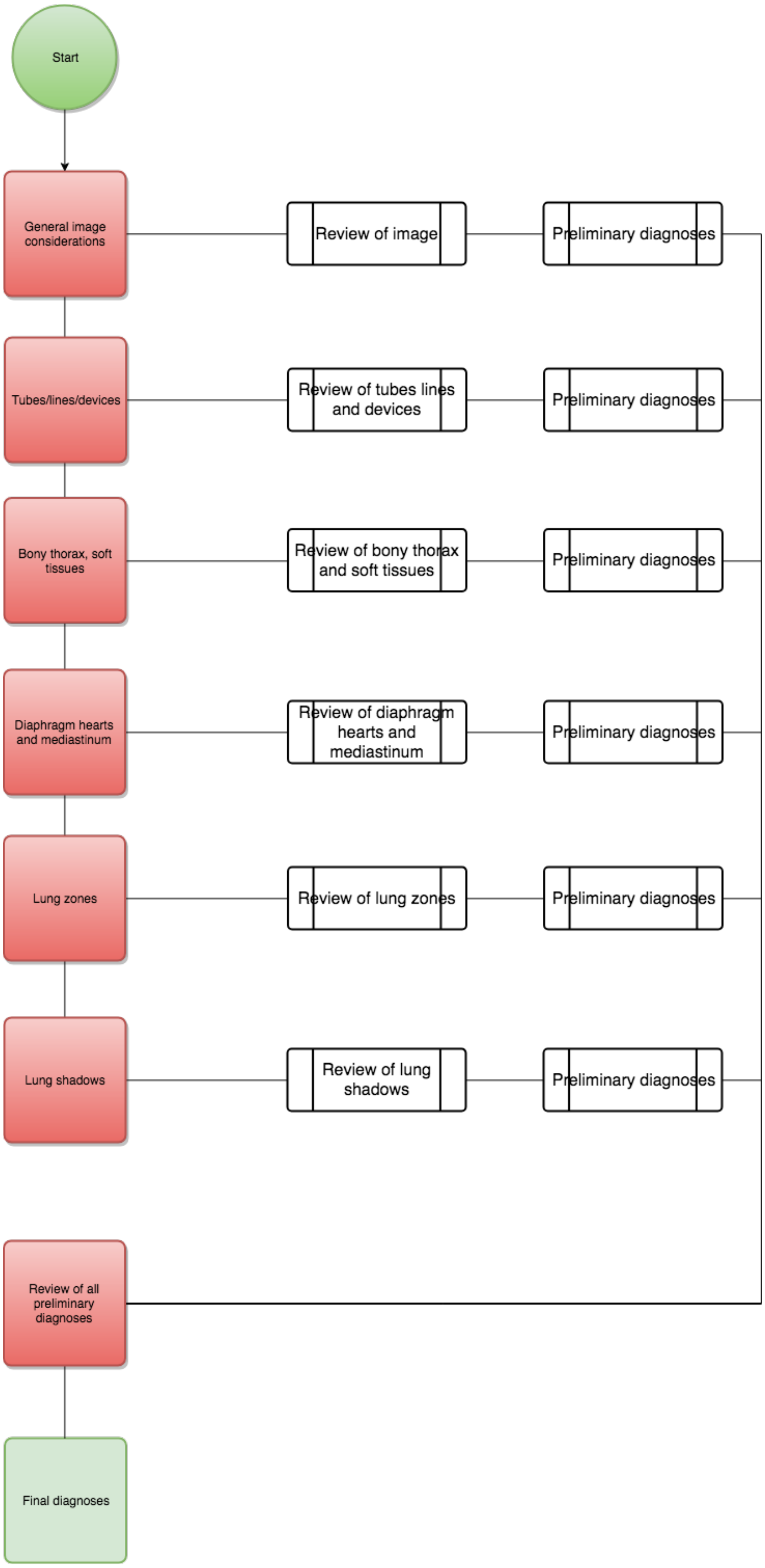

Figure 7.6a. Diagram illustrating the modular components of the radiographic system.

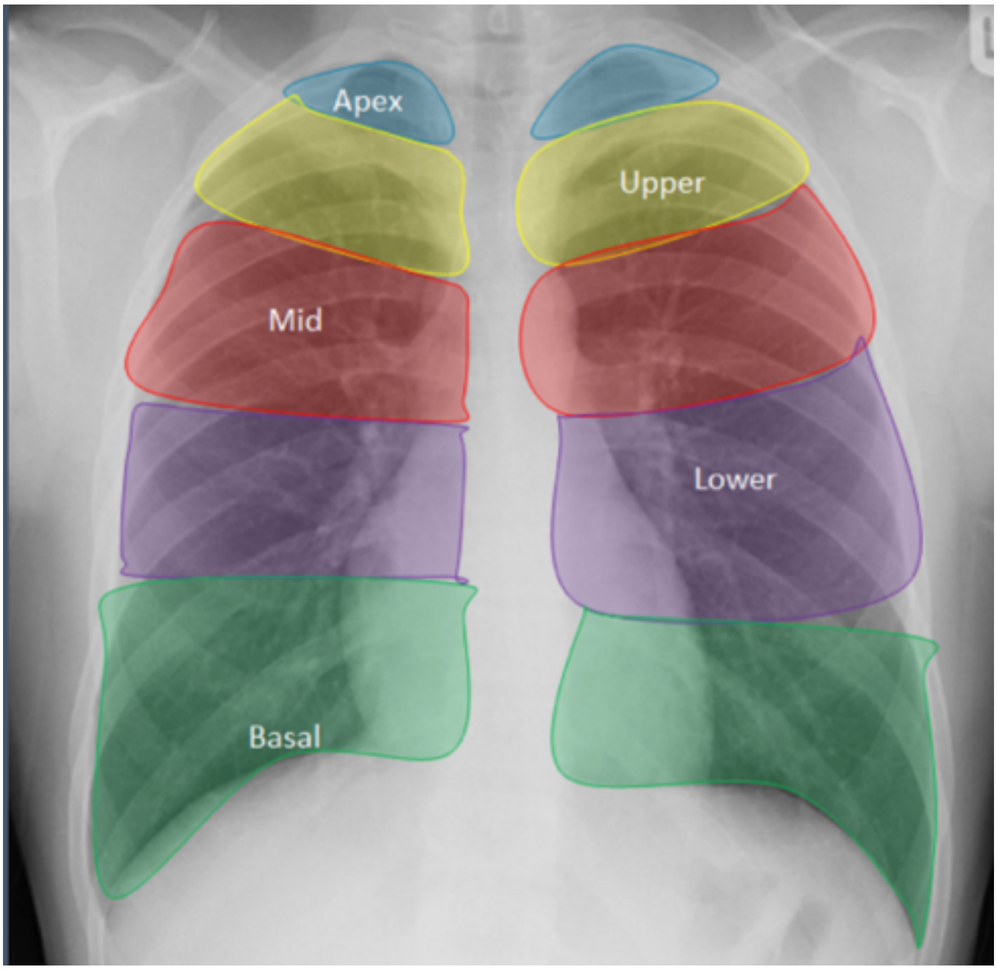

Figure 7.6b. Radiographic image illustrating a prompt within the system to remind interpreters of chest regions. Similar prompts were used within the IPI and IPI+DDA systems to focus a user interpretation.

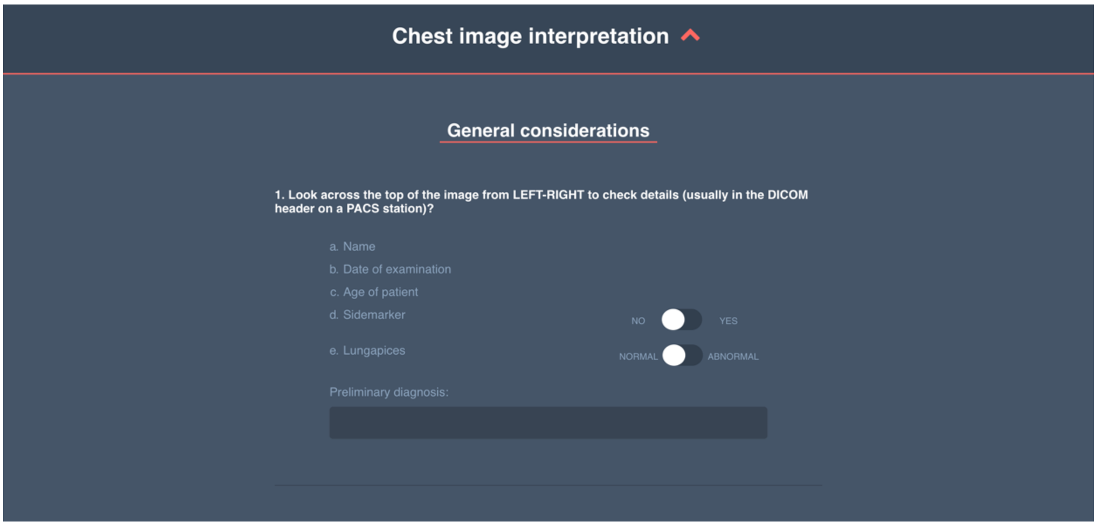

Figure 7.7. Image of system presentation illustrating general consideration an interpreter should adopt when interpreting a radiographic chest image.

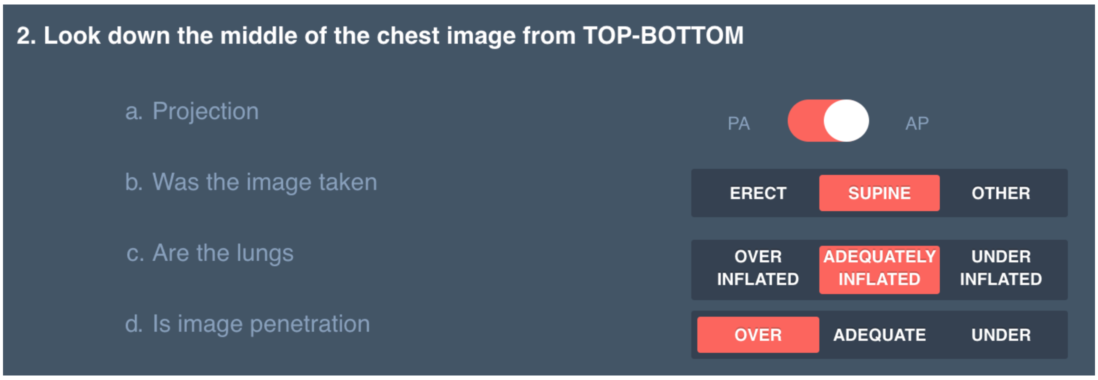

Figure 7.8. Image of system presentation illustrating annotations collected by interpreters when interpreting a radiographic chest image.

Equivalently, annotation collection is conducted at each stage of interpretation in the form of preliminary diagnoses. As within the IPI+DDA system, these annotations are collected and used dynamically to encourage differential diagnosis. This collection of preliminary diagnoses is presented to the interpreter before a final diagnosis is required as exemplified in Figure 7.9.

Following the creation of this study, it is clear key concepts within this thesis, such as the development of a digital checklist within a search strategy, are applicable across domains.

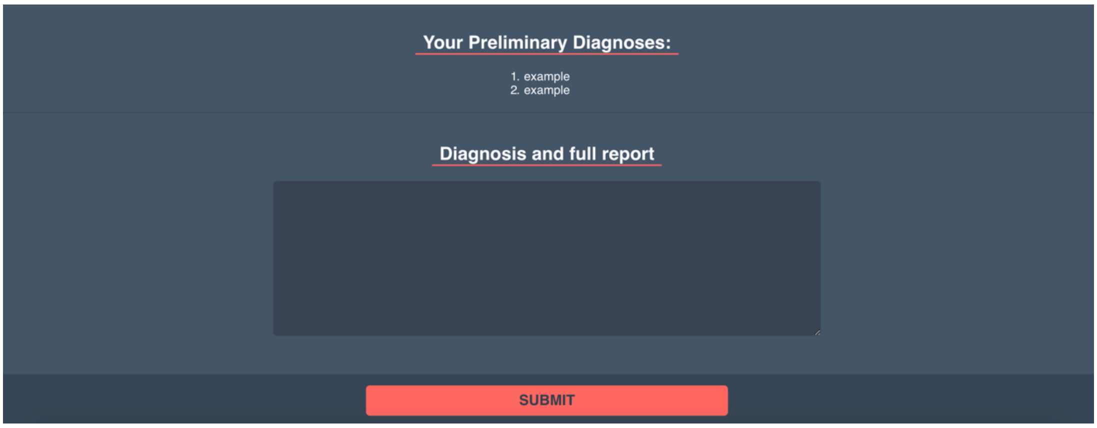

Figure 7.9. Image of system presentation illustrating the display of preliminary diagnoses and diagnostic report collection from a user when interpreting a radiographic chest image.

Platform elements were created using the same technology as the IPI system and the IPI+DDA system. Technologies include; HTML5, CSS3, PHP, JavaScript, JQuery and AJAX. A MySQL database was used to store interpretation data.

Papers on the model design, study protocols, and study results are forthcoming.

7.3 Limitations and future work

Within this research, analysis was not undertaken to compare the IPI+DDA system against results from the previous IPI study conducted without the DDA [23]. This decision was taken for several reasons; 1) participants taking part were from different cohorts, 2) each study had a different experimental design (two arm vs. counter balance), and 3) the starting interpretation ability within the IPI cohort without the DDA is superior. With this in mind, we have noted that overall accuracy did not improve between the IPI and IPI+DDA methods.

7.3.1 Limitations within the IPI study

A limitation of this study is the absence of a clinical scenario accompanying each ECG. It is apparent from numerous studies how a clinical scenario and other patient factors (e.g. chest pain) can improve diagnostic accuracy [4], [12], [21], [86], [87]. However, ECGs are not exclusively interpreted in a clinical context and therefore it was decided to not include a clinical scenario as this study was conducted to assess clinical ECG interpretation rather than full diagnoses.

However, one such strength of this study is the varied occupation of experienced participants with an average of more than 10 years' experience (control cohort = 10.2 years' experience, IPI cohort = 12.1 years' experience). Nevertheless, the number of participants was relatively low (Control n=11, IPI n=20). Participant cohort assignment could have been more evenly distributed. However, due to the IPI system being time consuming not all interpreters competed all 10 ECGs and therefore more interpreters were required to attain a comparative number of interpretations.

The drop-out rate of participants using the IPI system has also been noted. This could result from several factors. 1) the workshops used for some interpreter participation may not have been entirely appropriate for ECG interpretation on mobile devices as they were often a secondary study being ran alongside an informal workshop to investigate diagnostic accuracy. This may have led to interpreters being impatient about conducting the primary study and therefore abandoning the IPI study earlier than expected. 2) Initial technical issues regarding the wireless internet connection required to operate the system on multiple devices became an issue. This was overcome in later sessions by creating a local network and using a local server to save the data. 3) The current development state of the IPI system design. The current version of the system design may have influenced interpreter completion rates. Presently, the system requires users to spend a significant amount of time measuring intervals and assessing morphology, of which users are expected to manually enter annotation recordings into text-fields on each webpage. This imputation may have become tiresome after spending time assessing each segment for each ECG. The measurement process could have been expedited with the use of a digital calliper. Following feedback from participants it was highlighted a calliper would have been accommodating for the retrieval of interval measurements from each ECG.

7.3.2 Limitations within the IPI+DDA study

It has been noted the IPI+DDA study has some equivocal limitations when compared with the IPI study. One such comparable limitation is the absence of a clinical scenario accompanying each ECG. Other limitations include relatively small numbers of ECGs used within the system for this study. Also, a relatively small number of interpreters with varied experience was also present. However, a respectable number of ECG interpretations was recorded. As a result, the statistical comparisons are widely not significant, which weakens any definitive conclusions. A further limitation is the lack of control in the gold standard for the ECG diagnoses used with the study.

Numerous adaptations could be made to enhance this system. Refinements could be made to the diagnostic criteria stored in the JSON object, for example, adding further specific criteria to help diagnose LVH, VT and SVT. A second enhancement could be to define and implement weightings to correspond with the importance of each diagnostic criterion in the JSON object allowing the DDA algorithm to improve how it ranks its suggestions. Thirdly, some annotations could be pre-calculated by accurate computerised analysis, this could decrease interpretation time and increase diagnostic accuracy. One further enhancement could be to create an interface to allow clinicians to edit/update diagnostic criteria following a verification process.

7.4 Concluding remarks

This research provides an important contribution to the understanding of human ECG interpretation. This was achieved by deconstructing the interpretation process into five conceptual steps, underpinned by the psychology of cognitive engineering. A model such as this has evident benefits to the student learning experience, potentially in the assessment of clinical competence, and in decision support. HCI interaction techniques, knowledge-base refinement and rule-based engine modifications could be further enhanced to reduce assessment time, and hence help to provide a pathway to future clinical adoption.

By combining interaction design with AI this thesis exemplifies how CDSSs can be used to enhance diagnostic performance within medicine.

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Appendix:

Appendix A: Series of Structured Language Queries (SQL) applied to the IPI system

SQL	Relational Algebra	Description
INSERT INTO users (trial_id, gender, age, occupation, experience, diagnosed_ecgs, user_browser, user_os)VALUES ($\boldsymbol{x}$)	USERS←USERS∪{trial_id, gender, age, occupation, experience, diagnosed_ecgs, user_browser, user_os}	Where $\boldsymbol{x}$ is a set of unique demographics collected from an interpreter through user input or device assessment. Query was used to log interpreter demographic data into the USERS table in the IPIS database
SELECT * FROM questions ORDER BY category_id	$\boldsymbol{\pi}_{\text{ID, ECG\_image, category\_id}}$ (questions)	Query returns all ECG segments for all ECGs. The query was used to populate most of the interfaces.
SELECT * FROM questions WHERE category_id = $\boldsymbol{x}$ LIMIT 1	$\boldsymbol{\pi}_{\text{ID, ECG\_image, category\_id}}\ \boldsymbol{\sigma}_{(\text{category\_id} = \boldsymbol{x})}$ (questions)	Where $\boldsymbol{x}$ is a unique identifier for ECG segment four. Query returns an additional rhythm strip for the current ECG. The query was used to populate part of the interfaces.
INSERT INTO button_log(user_id, page_number, previous_button, next_button, image_press) VALUES ($\boldsymbol{x}$)	BUTTON_LOG←BUTTON_LOG∪{user_id, page_number, previous_button, next_button, image_press}	Where $\boldsymbol{x}$ is a set of unique answers given for each question. Query was used to log interpreter button press data into a the BUTTON_LOG table in the IPIS database
INSERT INTO user_answers(user_id, category_id, time_start, S1_Q1_rhythm, S1_Q2_heart_rate, S1_Q3_qrs_association, S1_Q4_sinus_radio, S1_time_end, S2_Q1_Pwave, S2_Q2_Pwave_duration, S2_Q3_Pwave_amplitude, S2_Q4_PR_interval, S2_Q5_PR_interval_value, S2_Q6_Pwave_normal, S2_time_end, S3_Q1_axis_value, S3_Q2_abnormality_radio, S3_Q3_Q_waves, S3_Q4_ST_elevation, S3_Q5_ST_depression, S3_Q6_T_waves, S3_time_end,	USER_ANSWERS←USER_ANSWERS∪{user_id, category_id, time_start, S1_Q1_rhythm, S1_Q2_heart_rate, S1_Q3_qrs_association, S1_Q4_sinus_radio, S1_time_end, S2_Q1_Pwave, S2_Q2_Pwave_duration, S2_Q3_Pwave_amplitude, S2_Q4_PR_interval, S2_Q5_PR_interval_value, S2_Q6_Pwave_normal, S2_time_end, S3_Q1_axis_value, S3_Q2_abnormality_radio, S3_Q3_Q_waves, S3_Q4_ST_elevation, S3_Q5_ST_depression, S3_Q6_T_waves, S3_time_end,	Where $\boldsymbol{x}$ is a set of unique answers given for each question. Query was used to log each interpreters answers to segment questions into the USER_ANSWERS table in the IPIS database. This query is repeated for each ECG interpreted.

S4_Q1_QRS_V1_duration, S4_Q2_QRS_V6_duration, S4_Q3_QT, S4_Q4_R, S4_Q5_QTc, S4_Q6_abnormality, S4_Q7_Q_waves, S4_Q8_ST_elevation, S4_Q9_ST_depression, S4_Q10_T_waves, S4_time_end, S5_Q1_R_wave, S5_Q2_chest_lead, S5_Q3_limb_lead, S5_diagnosis, S5_time_end, conf_level) VALUES ($\boldsymbol{x}$)	S4_Q1_QRS_V1_duration, S4_Q2_QRS_V6_duration, S4_Q3_QT, S4_Q4_R, S4_Q5_QTc, S4_Q6_abnormality, S4_Q7_Q_waves, S4_Q8_ST_elevation, S4_Q9_ST_depression, S4_Q10_T_waves, S4_time_end, S5_Q1_R_wave, S5_Q2_chest_lead, S5_Q3_limb_lead, S5_diagnosis, S5_time_end, conf_level}

Table 8.1 illustrating the IPI SQL insert queries alongside its relative relational algebra and brief description (where σ = selection, π = projection, $\leftarrow$ = insert assignment).

Appendix B: Source code for IPI model and Rule Based Algorithm

The code exemplified with the tables below contains the source code which was used to create IPI+DDA system. The source code which formed the IPI system is part thereof.

questions.php

```
<?php session_start(); ?><?php require '../config.php';
$timestart=round(microtime(true) * 1000); $category='';
if(!empty($_POST['gender'])){ $trial_id=$_POST['trial_id'];
$gender=$_POST['gender']; $age=$_POST['age']; $occupation=$_POST['occupation'];
$experience=$_POST['experience']; $diagnosed_ecgs=$_POST['ecg_number'];
$consent=$_POST['consent']; $user_browser=$_POST['user_browser'];
$user_os=$_POST['user_os']; if (!mysqli_query($con, "INSERT INTO users (trial_id,
gender, age, occupation, experience, diagnosed_ecgs, consent, user_browser,
user_os)VALUES ('$trial_id', '$gender', '$age', '$occupation', '$experience',
'$diagnosed_ecgs', '$consent', '$user_browser', '$user_os')")) {
printf("Errormessage: %sn", mysqli_error($con)); }; $_SESSION['id'] =
mysql_insert_id($con); } if(!empty($_SESSION['id'])){ ?> <!DOCTYPE
html><html><head><title>IPIS (Interactive progressive-based ECG
interpretation)</title> <script>var date_start=new Date();</script> <meta
name="viewport" content="width=device-width, initial-scale=1.0"><link
rel="stylesheet" href="fonts/font-awesome/css/font-awesome.min.css"><link
href="http://ajax.googleapis.com/ajax/libs/jqueryui/1.9.0/themes/cupertino/jquery-
```

```
ui.css" rel="stylesheet"><link href="css/bootstrap.min.css" rel="stylesheet" media="screen"><link rel="stylesheet" href="js/jquery-ui.css" /><link href="css/style.css" rel="stylesheet" media="screen"> <script src="js/jquery-1.10.2.min.js"></script> <script src="js/jquery-ui.min.js"></script> <script src='js/jquery.zoom.js'></script> <script src="js/main.js"></script> <script src="js/suggest.js"></script> <script src="js/bootstrap.min.js"></script> <script src="js/jquery.validate.min.js"></script> <script src="js/jquery-validate.bootstrap-tooltip.js"></script> <script src="js/roundslider.js"></script> <link href="js/roundslider.css" rel="stylesheet" /></head><body><div id="loading"> <img id="loading-image" src="images/loading.gif" alt="Loading..." /></div><form class="form-horizontal" role="form" id='questions' method="post" action="result.php"> <input type="hidden" id="dateStart" name="timestart" value="1"> <?php $res = mysqli_query($con, "select * from questions WHERE category_id > 5 order by category_id") or die(mysqli_error($con)); $rows = mysqli_num_rows($res); $i=1;while($result=mysqli_fetch_array($res)){?> <?php if($i==1 || $i==6 || $i==11 || $i==16 || $i==21){?><div id="section_ending_<?php echo $i+4;?>" class="outer-element"><div id='question<?php echo $i;?>' class='cont'> <section class="img-block"><div class="shadow"></div><div class="hint bounce"><i title="Scroll to show more of the rhythm strip" class="fa fa-arrows-h"></i></div><div class="content-wrapper"> <img title="Scroll to show more of the rhythm strip" src="<?php echo $result['ECG_image'];?>" /> <input type="hidden" value="<?php echo $i;?>" class="image-page-number"></div> </section><div class="section-title">Prompt: Interpret the rhythm strip</div><div class="container"><div class="content-section"><h4 class="headings">Questions:</h4><div class="question-block"><p>Is the rhythm regular?</p><div class="input-section"> <span>No</span><div class="switch"> <input type="hidden" name="category_<?php echo $result['category_id'];?>_S1_Q1_rhythm" value="Not regular" /> <input type="checkbox" class="cmn-toggle cmn-toggle-round sug-regular-rhythm" value="Regular" id='category_<?php echo $result['category_id'];?>_regular' name='category_<?php echo $result['category_id'];?>_S1_Q1_rhythm' > <label for="category_<?php echo $result['category_id'];?>_regular"></label></div> <span>Yes</span></div></div><div class="question-block"><p>What is the heart rate</p><div class="input-section"> <output for='category_<?php echo $result['category_id'];?>_S1_Q2_heart_rate' id='category_<?php echo $result['category_id'];?>_S1_Q2_heart_rate_output'>80 </output> <span> bpm</span></div> <input type='range' min='0' max='160' value="80" step='1' id='category_<?php echo $result['category_id'];?>_S1_Q2_heart_rate' name='category_<?php echo $result['category_id'];?>_S1_Q2_heart_rate' oninput="rangeUpdate('value', this)" onchange="rangeUpdate('value', this)" class="sug-HR range-input-category-<?php echo $result['category_id'];?>"></div><div class="question-block"><p class="multi-line">Are the QRS complexes associated with the P waves?</p><div class="input-section"> <span>No</span><div class="switch"> <input type="hidden" name="category_<?php echo $result['category_id'];?>_S1_Q3_qrs_association" value="No" /> <input type="checkbox" class="cmn-toggle cmn-toggle-round sug-P-QRS-association" value="Yes" id='category_<?php echo $result['category_id'];?>_qrs_association' name='category_<?php echo $result['category_id'];?>_S1_Q3_qrs_association' > <label for="category_<?php echo $result['category_id'];?>_qrs_association"></label></div> <span>Yes</span></div></div><div class="question-block"><p>Is this Sinus Rhythm?</p><div class="input-section"> <span>No</span><div class="switch"> <input type="hidden" name="category_<?php echo $result['category_id'];?>_S1_Q4_sinus_radio" value="No" /> <input type="checkbox"
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class="cmn-toggle cmn-toggle-round sug-sinus" value="Yes" id='category_<?php echo
$result['category_id'];?>_not_sinus' name='category_<?php echo
$result['category_id'];?>_S1_Q4_sinus_radio' > <label for="category_<?php echo
$result['category_id'];?>_not_sinus"></label></div> <span>Yes</span></div></div>
<input type="hidden" id='category_<?php echo $result['category_id'];?>'
name="category_<?php echo $result['category_id'];?>" value="<?php echo
$result['category_id'];?>"></input> <input type="hidden" id='category_<?php echo
$result['category_id'];?>_S1_time_end' name="category_<?php echo
$result['category_id'];?>_S1_time_end"></input></div></div><div class="footer">
<button class='previous faded btn' type='button'>Previous</button><h3 class="place-
description">Part 1/5</h3> <button value="" id='<?php echo $i;?>' type='button'
class='next btn btn-success' onclick="getElementById('category_<?php echo
$result['category_id'];?>_S1_time_end').value= '+' + ((new Date() -
date_start)/1000).toString(); this.value= '+' + ((new Date() -
date_start)/1000).toString()" >Next</button> <input type="hidden" value="<?php echo
$i;?>" class="ecg-part"></div></div><?php }elseif($i==2 || $i==7 || $i==12 || $i==17
|| $i==22 ){?><div id='question<?php echo $i;?>' class='cont'> <section class="img-
block scale"> <img title="P-wave" src="<?php echo $result['ECG_image'];?>" /> <input
type="hidden" value="<?php echo $i;?>" class="image-page-number"> </section><div
class="section-title">Prompt: Interpret the P-Wave morphology</div><div
class="container"><div class="content-section"><h4
class="headings">Questions:</h4><div class="question-block"><p>Is there a P-
Wave?</p><div class="input-section"> <span>No</span><div class="switch"> <input
type="hidden" name='category_<?php echo $result['category_id'];?>_S2_Q1_Pwave'
value="No" /> <input type="checkbox" class="cmn-toggle cmn-toggle-round sug-P-wave-
present" value="Yes" id='category_<?php echo $result['category_id'];?>_P_wave'
name='category_<?php echo $result['category_id'];?>_S2_Q1_Pwave'> <label class="p-
wave-toggle" for="category_<?php echo
$result['category_id'];?>_P_wave"></label></div> <span>Yes</span></div></div><div
class="active-reveal question-block"><p class="multi-line">Select which wave is
present:</p><div class="radio-switch no-p-wave"> <input id="category_<?php echo
$result['category_id'];?>_S2_Q2_Pwave_flutter" type="radio" name="category_<?php
echo $result['category_id'];?>_S2_Q2_Pwave_type" value="flutter" class="form-
control radio-switch-input sug-p-wave-type" > <label for="category_<?php echo
$result['category_id'];?>_S2_Q2_Pwave_flutter" class="radio-switch-label number-
diagnosed"><img src="images/p-wave/p-waves-flutter.png">Flutter</label> <input
id="category_<?php echo $result['category_id'];?>_S2_Q2_Pwave_fib" type="radio"
name="category_<?php echo $result['category_id'];?>_S2_Q2_Pwave_type"
value="fibrillation" class="form-control radio-switch-input sug-p-wave-type" >
<label for="category_<?php echo $result['category_id'];?>_S2_Q2_Pwave_fib"
class="radio-switch-label number-diagnosed"><img src="images/p-wave/p-waves-
fib.png">Fibrillation</label> <input id="category_<?php echo
$result['category_id'];?>_S2_Q2_Pwave_other" type="radio" name="category_<?php echo
$result['category_id'];?>_S2_Q2_Pwave_type" value="other" class="form-control
radio-switch-input sug-p-wave-type" > <label for="category_<?php echo
$result['category_id'];?>_S2_Q2_Pwave_other" class="radio-switch-label number-
diagnosed"><img src="images/p-wave/p-waves-other.png">Other</label> <input
id="category_<?php echo $result['category_id'];?>_S2_Q2_Pwave_none" type="radio"
name="category_<?php echo $result['category_id'];?>_S2_Q2_Pwave_type" value="none"
class="form-control radio-switch-input sug-p-wave-type" checked > <label
for="category_<?php echo $result['category_id'];?>_S2_Q2_Pwave_none" class="radio-
switch-label number-diagnosed"><img src="images/p-wave/p-waves-none.png">No P-
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wave</label></div></div><div class="reveal-if-active question-block"><p
class="image-radio-toggle">What form does the P-wave take:</p><div class="radio-
switch"> <input id="category_<?php echo
$result['category_id'];?>_S2_Q2_Pwave_normal" type="radio" name="category_<?php
echo $result['category_id'];?>_S2_Q2_Pwave_type" value="normal" class="form-control
radio-switch-input sug-p-wave-type"> <label for="category_<?php echo
$result['category_id'];?>_S2_Q2_Pwave_normal" class="radio-switch-label number-
diagnosed"> <img src="images/p-wave/p-waves-normal.png"> Normal P-wave</label>
<input id="category_<?php echo $result['category_id'];?>_S2_Q2_Pwave_pulmonale"
type="radio" name="category_<?php echo $result['category_id'];?>_S2_Q2_Pwave_type"
value="pulmonale" class="form-control radio-switch-input sug-p-wave-type" > <label
for="category_<?php echo $result['category_id'];?>_S2_Q2_Pwave_pulmonale"
class="radio-switch-label number-diagnosed"><img src="images/p-wave/p-waves-
pulmonale.png">Pulmonale</label> <input id="category_<?php echo
$result['category_id'];?>_S2_Q2_Pwave_mitrale" type="radio" name="category_<?php
echo $result['category_id'];?>_S2_Q2_Pwave_type" value="mitrale" class="form-
control radio-switch-input sug-p-wave-type" > <label for="category_<?php echo
$result['category_id'];?>_S2_Q2_Pwave_mitrale" class="radio-switch-label number-
diagnosed"><img src="images/p-wave/p-waves-mitrale.png">Mitrale</label> <input
id="category_<?php echo $result['category_id'];?>_S2_Q2_Pwave_biphasic"
type="radio" name="category_<?php echo $result['category_id'];?>_S2_Q2_Pwave_type"
value="biphasic" class="form-control radio-switch-input sug-p-wave-type" > <label
for="category_<?php echo $result['category_id'];?>_S2_Q2_Pwave_biphasic"
class="radio-switch-label number-diagnosed"><img src="images/p-wave/p-waves-
biphasic.png">Biphasic</label></div><hr class="clear"><div class="question-
block"><p class="height-standard">What is the duration of the P-wave:</p><div
class="input-section"> <output for='category_<?php echo
$result['category_id'];?>_S2_Q3_Pwave_duration' id='category_<?php echo
$result['category_id'];?>_S2_Q3_Pwave_duration_output'>0.12</output> <span>
S</span></div> <input type='range' min='0' max='0.24' value="0.12" step='0.01'
class="p-wave p-wave-dur range-input-category-<?php echo $result['category_id'];?>
sug-p-wave-dur" id="category_<?php echo
$result['category_id'];?>_S2_Q3_Pwave_duration" name="category_<?php echo
$result['category_id'];?>_S2_Q3_Pwave_duration" oninput="rangeUpdate('value',
this)" onchange="rangeUpdate('value', this)"></div><div class="question-block"><p
class="height-standard">What is the amplitude of the P-wave:</p><div class="input-
section"> <output for='category_<?php echo
$result['category_id'];?>_S2_Q4_Pwave_amplitude' id='category_<?php echo
$result['category_id'];?>_S2_Q4_Pwave_amplitude_output'>2.5 </output> <span>
mV</span></div> <input type='range' min='0' max='5' value='2.5' step='0.01'
class="p-wave p-wave-amp range-input-category-<?php echo $result['category_id'];?>
sug-p-wave-amp" id="category_<?php echo
$result['category_id'];?>_S2_Q4_Pwave_amplitude" name="category_<?php echo
$result['category_id'];?>_S2_Q4_Pwave_amplitude" oninput="rangeUpdate('value',
this)" onchange="rangeUpdate('value', this)"></div><p class="pwave-result"></p><hr
class="clear"><div class="question-block"><p>Is the PR interval varying?</p><div
class="input-section"> <span>No</span><div class="switch"> <input type="hidden"
name='category_<?php echo $result['category_id'];?>_S2_Q5_PR_interval' value="No"
/> <input type="checkbox" class="cmn-toggle cmn-toggle-round sug-PR-interval-
variation" value="Yes" id='category_<?php echo
$result['category_id'];?>_PR_interval' name='category_<?php echo
$result['category_id'];?>_S2_Q5_PR_interval'> <label for="category_<?php echo
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$result['category_id'];?>_PR_interval"></label></div>
<span>Yes</span></div></div><div class="question-block"><p class="height-standard">What is the PR interval:</p><div class="input-section"> <output for='category_<?php echo $result['category_id'];?>_S2_Q6_PR_interval' id='category_<?php echo $result['category_id'];?>_S2_Q6_PR_interval_output'>0.16 </output> <span> S</span></div> <input type='range' min='0' max='0.32' value='0.16' step='0.01' id="category_<?php echo $result['category_id'];?>_S2_Q6_PR_interval" name="category_<?php echo $result['category_id'];?>_S2_Q6_PR_interval_value" class="range-input-category-<?php echo $result['category_id'];?> sug-pr-interval" oninput="rangeUpdate('value', this)" onchange="rangeUpdate('value', this)"></div></div> <input type="hidden" id='category_<?php echo $result['category_id'];?>_S2_time_end' name="category_<?php echo $result['category_id'];?>_S2_time_end"></input></div></div><div class="footer"> <button id='<?php echo $i;?>' class='previous btn btn-success' type='button' onclick="this.value= '+' + ((new Date() - date_start)/1000).toString()">Previous</button><h3 class="place-description">Part 2/5</h3> <button id='<?php echo $i;?>' class='next btn btn-success' type='button' onclick="getElementById('category_<?php echo $result['category_id'];?>_S2_time_end').value= '+' + ((new Date() - date_start)/1000).toString(); this.value= '+' + ((new Date() - date_start)/1000).toString()">Next</button> <input type="hidden" value="<?php echo $i;?>" class="ecg-part"></div></div><?php }elseif($i==3 || $i==8 || $i==13 || $i==18 || $i==23 ){?><div id='question<?php echo $i;?>' class='cont'> <section class="img-block scale"> <img title="Limb leads" src="<?php echo $result['ECG_image'];?>" /> <input type="hidden" value="<?php echo $i;?>" class="image-page-number"> </section><div class="section-title">Prompt: Interpret the limb leads</div><div class="container"><div class="content-section"><h4 class="headings">Questions:</h4><div class="question-block"><p class="full-width-line centre">Adjust the axis below to illustrate the cardiac axis in degrees:</p><div id="category_<?php echo $result['category_id'];?>_S3_Q1_axis_value" class="axis-indication"></div><p class="axis-result"><span class="axis-value">Measurement is <strong><span>normal</span></strong></span></p></div><div class="question-block "><div class="question-block full-width"><p class="multi-line">Are there abnormal <strong>Q Waves?</strong></p><div class="input-section"> <span>No</span><div class="switch"> <input type="hidden" name='category_<?php echo $result['category_id'];?>_S3_Q2_q_waves' value="No" /> <input type="checkbox" class="cmn-toggle cmn-toggle-round sug-q-wave-1" value="Yes" id='category_<?php echo $result['category_id'];?>_S3_Q2_q_waves' name='category_<?php echo $result['category_id'];?>_S3_Q2_q_waves'> <label class="checkbox-toggle" for="category_<?php echo $result['category_id'];?>_S3_Q2_q_waves"></label></div>
<span>Yes</span></div><div class="reveal-if-active checkbox-block"><p class="full-width-line">Which leads have abnormal <strong>Q waves?</strong></p><div class="checkbox-element"><p>I:</p> <input type="checkbox" value="Lead_I" class="lead-checkbox sug-q-wave-I" id="category_<?php echo $result['category_id'];?>_checkbox_Q1" name="category_<?php echo $result['category_id'];?>_S3_Q2_Q_wave_leads[]"/> <label for="category_<?php echo $result['category_id'];?>_checkbox_Q1"></label></div><div class="checkbox-element"><p>II:</p> <input type="checkbox" value="Lead_II" class="lead-checkbox sug-q-wave-II" id="category_<?php echo $result['category_id'];?>_checkbox_Q2" name="category_<?php echo $result['category_id'];?>_S3_Q2_Q_wave_leads[]" /> <label for="category_<?php echo $result['category_id'];?>_checkbox_Q2"></label></div><div class="checkbox-element"><p>III:</p> <input type="checkbox" value="Lead_III"
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class="lead-checkbox sug-q-wave-III" id="category_<?php echo
$result['category_id'];?>_checkbox_Q3" name="category_<?php echo
$result['category_id'];?>_S3_Q2_Q_wave_leads[]" /> <label for="category_<?php echo
$result['category_id'];?>_checkbox_Q3"></label></div><div class="checkbox-
element"><p>aVR:</p> <input type="checkbox" value="aVR" class="lead-checkbox sug-q-
wave-aVR" id="category_<?php echo $result['category_id'];?>_checkbox_Q4"
name="category_<?php echo $result['category_id'];?>_S3_Q2_Q_wave_leads[]" /> <label
for="category_<?php echo $result['category_id'];?>_checkbox_Q4"></label></div><div
class="checkbox-element"><p>aVL:</p> <input type="checkbox" value="aVL"
class="lead-checkbox sug-q-wave-aVL" id="category_<?php echo
$result['category_id'];?>_checkbox_Q5" name="category_<?php echo
$result['category_id'];?>_S3_Q2_Q_wave_leads[]" /> <label for="category_<?php echo
$result['category_id'];?>_checkbox_Q5"></label></div><div class="checkbox-
element"><p>aVF:</p> <input type="checkbox" value="aVF" class="lead-checkbox sug-q-
wave-aVF" id="category_<?php echo $result['category_id'];?>_checkbox_Q6"
name="category_<?php echo $result['category_id'];?>_S3_Q2_Q_wave_leads[]" /> <label
for="category_<?php echo
$result['category_id'];?>_checkbox_Q6"></label></div></div></div><div
class="question-block full-width mt-20"><p class="multi-line">Is there abnormal
<strong>ST-segment elevation?</strong></p><div class="input-section">
<span>No</span><div class="switch"> <input type="hidden" name='category_<?php echo
$result['category_id'];?>_S3_Q3_st_segment' value="No" /> <input type="checkbox"
class="cmn-toggle cmn-toggle-round sug-st-elevation-1" value="Yes"
id='category_<?php echo $result['category_id'];?>_S3_Q3_st_segment'
name='category_<?php echo $result['category_id'];?>_S3_Q3_st_segment'> <label
class="checkbox-toggle" for="category_<?php echo
$result['category_id'];?>_S3_Q3_st_segment"></label></div>
<span>Yes</span></div><div class="reveal-if-active checkbox-block"><p class="full-
width-line">Which leads have abnormal <strong>ST-segment elevation?</strong></p><div
class="checkbox-element"><p> I:</p> <input type="checkbox" value="Lead_I"
class="lead-checkbox sug-st-elevation-I" id="category_<?php echo
$result['category_id'];?>_checkbox_Q7" name="category_<?php echo
$result['category_id'];?>_S3_Q3_st_segment_leads[]"/> <label for="category_<?php
echo $result['category_id'];?>_checkbox_Q7"></label></div><div class="checkbox-
element"><p>II:</p> <input type="checkbox" value="Lead_II" class="lead-checkbox sug-
st-elevation-II" id="category_<?php echo $result['category_id'];?>_checkbox_Q8"
name="category_<?php echo $result['category_id'];?>_S3_Q3_st_segment_leads[]" />
<label for="category_<?php echo
$result['category_id'];?>_checkbox_Q8"></label></div><div class="checkbox-
element"><p>III:</p> <input type="checkbox" value="Lead_III" class="lead-checkbox
sug-st-elevation-III" id="category_<?php echo
$result['category_id'];?>_checkbox_Q9" name="category_<?php echo
$result['category_id'];?>_S3_Q3_st_segment_leads[]" /> <label for="category_<?php
echo $result['category_id'];?>_checkbox_Q9"></label></div><div class="checkbox-
element"><p>aVR:</p> <input type="checkbox" value="aVR" class="lead-checkbox sug-
st-elevation-aVR" id="category_<?php echo $result['category_id'];?>_checkbox_Q10"
name="category_<?php echo $result['category_id'];?>_S3_Q3_st_segment_leads[]" />
<label for="category_<?php echo
$result['category_id'];?>_checkbox_Q10"></label></div><div class="checkbox-
element"><p>aVL:</p> <input type="checkbox" value="aVL" class="lead-checkbox sug-
st-elevation-aVL" id="category_<?php echo $result['category_id'];?>_checkbox_Q11"
name="category_<?php echo $result['category_id'];?>_S3_Q3_st_segment_leads[]" />
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<label for="category_<?php echo
$result['category_id'];?>_checkbox_Q11"></label></div><div class="checkbox-
element"><p>aVF:</p> <input type="checkbox" value="aVF" class="lead-checkbox sug-
st-elevation-aVF" id="category_<?php echo $result['category_id'];?>_checkbox_Q12"
name="category_<?php echo $result['category_id'];?>_S3_Q3_st_segment_leads[]" />
<label for="category_<?php echo
$result['category_id'];?>_checkbox_Q12"></label></div></div></div><div
class="question-block full-width mt-20"><p class="multi-line">Is there abnormal
<strong>ST-segment depression?</strong></p><div class="input-section">
<span>No</span><div class="switch"> <input type="hidden" name='category_<?php echo
$result['category_id'];?>_S3_Q4_st_segment_dep' value="No" /> <input
type="checkbox" class="cmn-toggle cmn-toggle-round sug-st-depression-1" value="Yes"
id='category_<?php echo $result['category_id'];?>_S3_Q4_st_segment_dep'
name='category_<?php echo $result['category_id'];?>_S3_Q4_st_segment_dep'> <label
class="checkbox-toggle" for="category_<?php echo
$result['category_id'];?>_S3_Q4_st_segment_dep"></label></div>
<span>Yes</span></div><div class="reveal-if-active checkbox-block"><p class="full-
width-line">Which leads have abnormal <strong>ST-segment
depression?</strong></p><div class="checkbox-element"><p>I:</p> <input
type="checkbox" value="Lead_I" class="lead-checkbox sug-st-depression-I"
id="category_<?php echo $result['category_id'];?>_checkbox_Q13"
name="category_<?php echo $result['category_id'];?>_S3_Q4_st_segment_dep_leads[]"/>
<label for="category_<?php echo
$result['category_id'];?>_checkbox_Q13"></label></div><div class="checkbox-
element"><p>II:</p> <input type="checkbox" value="Lead_II" class="lead-checkbox sug-
st-depression-II" id="category_<?php echo $result['category_id'];?>_checkbox_Q14"
name="category_<?php echo $result['category_id'];?>_S3_Q4_st_segment_dep_leads[]"
/> <label for="category_<?php echo
$result['category_id'];?>_checkbox_Q14"></label></div><div class="checkbox-
element"><p>III:</p> <input type="checkbox" value="Lead_III" class="lead-checkbox
sug-st-depression-III" id="category_<?php echo
$result['category_id'];?>_checkbox_Q15" name="category_<?php echo
$result['category_id'];?>_S3_Q4_st_segment_dep_leads[]" /> <label
for="category_<?php echo $result['category_id'];?>_checkbox_Q15"></label></div><div
class="checkbox-element"><p>aVR:</p> <input type="checkbox" value="aVR"
class="lead-checkbox sug-st-depression-aVR" id="category_<?php echo
$result['category_id'];?>_checkbox_Q16" name="category_<?php echo
$result['category_id'];?>_S3_Q4_st_segment_dep_leads[]" /> <label
for="category_<?php echo $result['category_id'];?>_checkbox_Q16"></label></div><div
class="checkbox-element"><p>aVL:</p> <input type="checkbox" value="aVL"
class="lead-checkbox sug-st-depression-aVL" id="category_<?php echo
$result['category_id'];?>_checkbox_Q17" name="category_<?php echo
$result['category_id'];?>_S3_Q4_st_segment_dep_leads[]" /> <label
for="category_<?php echo $result['category_id'];?>_checkbox_Q17"></label></div><div
class="checkbox-element"><p>aVF:</p> <input type="checkbox" value="aVF"
class="lead-checkbox sug-st-depression-aVF" id="category_<?php echo
$result['category_id'];?>_checkbox_Q18" name="category_<?php echo
$result['category_id'];?>_S3_Q4_st_segment_dep_leads[]" /> <label
for="category_<?php echo
$result['category_id'];?>_checkbox_Q18"></label></div></div></div><div
class="question-block full-width mt-20"><p class="multi-line">Are there abnormal
<strong>T-waves?</strong></p><div class="input-section"> <span>No</span><div
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class="switch">      <input      type="hidden"      name='category_<?php      echo
$result['category_id'];?>_S3_Q5_t_wave'  value="No"  />  <input  type="checkbox"
class="cmn-toggle     cmn-toggle-round     sug-t-wave-abnormal-1"     value="Yes"
id='category_<?php          echo          $result['category_id'];?>_S3_Q5_t_wave'
name='category_<?php    echo    $result['category_id'];?>_S3_Q5_t_wave'>    <label
class="checkbox-toggle"                   for="category_<?php                 echo
$result['category_id'];?>_S3_Q5_t_wave"></label></div>   <span>Yes</span></div><div
class="reveal-if-active checkbox-block"><p class="full-width-line">Which leads have
abnormal   <strong>T   waves?</strong></p><div   class="checkbox-element"><p>I:</p>
<input  type="checkbox"  value="Lead_I"  class="lead-checkbox  sug-t-wave-abnormal-I"
id="category_<?php          echo          $result['category_id'];?>_checkbox_Q19"
name="category_<?php echo $result['category_id'];?>_S3_Q5_t_wave_leads[]"/> <label
for="category_<?php echo $result['category_id'];?>_checkbox_Q19"></label></div><div
class="checkbox-element"><p>II:</p>    <input    type="checkbox"    value="Lead_II"
class="lead-checkbox     sug-t-wave-abnormal-II"     id="category_<?php     echo
$result['category_id'];?>_checkbox_Q20"         name="category_<?php         echo
$result['category_id'];?>_S3_Q5_t_wave_leads[]" /> <label for="category_<?php echo
$result['category_id'];?>_checkbox_Q20"></label></div><div        class="checkbox-
element"><p>III:</p> <input type="checkbox" value="Lead_III" class="lead-checkbox
sug-t-wave-abnormal-III"                  id="category_<?php                 echo
$result['category_id'];?>_checkbox_Q21"         name="category_<?php         echo
$result['category_id'];?>_S3_Q5_t_wave_leads[]" /> <label for="category_<?php echo
$result['category_id'];?>_checkbox_Q21"></label></div><div        class="checkbox-
element"><p>aVR:</p> <input type="checkbox" value="aVR" class="lead-checkbox sug-t-
wave-abnormal-aVR" id="category_<?php echo $result['category_id'];?>_checkbox_Q22"
name="category_<?php echo $result['category_id'];?>_S3_Q5_t_wave_leads[]" /> <label
for="category_<?php echo $result['category_id'];?>_checkbox_Q22"></label></div><div
class="checkbox-element"><p>aVL:</p>     <input     type="checkbox"     value="aVL"
class="lead-checkbox     sug-t-wave-abnormal-aVL"     id="category_<?php     echo
$result['category_id'];?>_checkbox_Q23"         name="category_<?php         echo
$result['category_id'];?>_S3_Q5_t_wave_leads[]" /> <label for="category_<?php echo
$result['category_id'];?>_checkbox_Q23"></label></div><div        class="checkbox-
element"><p>aVF:</p> <input type="checkbox" value="aVF" class="lead-checkbox sug-t-
wave-abnormal-aVF" id="category_<?php echo $result['category_id'];?>_checkbox_Q24"
name="category_<?php echo $result['category_id'];?>_S3_Q5_t_wave_leads[]" /> <label
for="category_<?php                                                          echo
$result['category_id'];?>_checkbox_Q24"></label></div></div></div></div></div>
<input type="hidden" id='category_<?php echo $result['category_id'];?>_S3_time_end'
name="category_<?php echo $result['category_id'];?>_S3_time_end"></input></div><div
class="footer">  <button  id='<?php  echo  $i;?>'  class='previous  btn  btn-success'
type='button'     onclick="this.value=     '+'     +     ((new     Date()     -
date_start)/1000).toString()">Previous</button><h3   class="place-description">Part
3/5</h3> <button id='<?php echo $i;?>' class='next btn btn-success' type='button'
onclick="getElementById('category_<?php                                      echo
$result['category_id'];?>_S3_time_end').value=    '+'    +    ((new    Date()    -
date_start)/1000).toString();    this.value=    '+'    +    ((new    Date()    -
date_start)/1000).toString()">Next</button> <input type="hidden" value="<?php echo
$i;?>" class="ecg-part"></div></div><?php }elseif($i==4 || $i==9 || $i==14 || $i==19
|| $i==24 ){?><div id='question<?php echo $i;?>' class='cont'> <section class="img-
block scale"> <img title="Chest leads" src="<?php echo $result['ECG_image'];?>" />
<input type="hidden" value="<?php echo $i;?>" class="image-page-number"> </section>
<section class="img-block secondary-img"> <?php $image_cat = $result['category_id'];
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$img_res = mysqli_query($con, "select * from questions where category_id =
'$image_cat' LIMIT 1") or die(mysqli_error($con)); $first_image_row =
mysqli_fetch_array($img_res); $S1 = $first_image_row['ECG_image']; ?> <img
src="<?php echo $S1 ?>" /> <input type="hidden" value="<?php echo $i;?>"
class="image-page-number"> </section><div class="section-title">Prompt: Interpret
the QRS morphology</div><div class="container"><div class="content-section"><h4
class="headings">Questions:</h4><div class="question-block"><div class="question-
block full-width"><p class="height-standard">What is the QRS Interval:</p><div
class="input-section"> <output for='category_<?php echo
$result['category_id'];?>_S4_Q1_QRS_duration' id='category_<?php echo
$result['category_id'];?>_S4_Q1_QRS_duration_output'>0.09 </output> <span>
s</span></div> <input type='range' min='0' max='0.18' value='0.09' step='0.01'
class="v6-QRS-duration sug-qrs-interval range-input-category-<?php echo
$result['category_id'];?>" id='category_<?php echo
$result['category_id'];?>_S4_Q1_QRS_duration' name='category_<?php echo
$result['category_id'];?>_S4_Q1_QRS_duration' oninput="rangeUpdate('value', this)"
onchange="rangeUpdate('value', this)"></div><hr style="clear: both;"/><div
class="question-block full-width"><p class="height-standard">What is the QT
Interval:</p><div class="input-section"> <output for='category_<?php echo
$result['category_id'];?>_S4_Q2_QT' id='category_<?php echo
$result['category_id'];?>_S4_Q2_QT_output'>0.4</output> <span> s</span></div>
<input type='range' min='0' max='0.8' value='0.4' step='0.01' class="qtc-calc qt-
duration range-input-category-<?php echo $result['category_id'];?> sug-qt-interval"
id='category_<?php echo $result['category_id'];?>_S4_Q2_QT' name='category_<?php
echo $result['category_id'];?>_S4_Q2_QT' oninput="rangeUpdate('value', this)"
onchange="rangeUpdate('value', this)"></div><div class="question-block full-
width"><p class="height-standard">What is the R-R Interval:</p><div class="input-
section"> <output for='category_<?php echo $result['category_id'];?>_S4_Q3_R'
id='category_<?php echo $result['category_id'];?>_S4_Q3_R_output'>1 </output>
<span> s</span></div> <input type='range' min='0' max='2' value='1' step='0.01'
class="qtc-calc rr-duration range-input-category-<?php echo
$result['category_id'];?> sug-rr-interval" id='category_<?php echo
$result['category_id'];?>_S4_Q3_R' name='category_<?php echo
$result['category_id'];?>_S4_Q3_R' oninput="rangeUpdate('value', this)"
onchange="rangeUpdate('value', this)"></div><div class="QTc-element"> <span>QTc =
</span> <input readonly type="text" class="QTc-output" name="category_<?php echo
$result['category_id'];?>_S4_Q4_QTc"> <span class="units">s</span></div></div><div
class="question-block"><div class="question-block full-width mt-20"><p
class="multi-line">Are there <strong>abnormal Q Waves?</strong></p><div
class="input-section"> <span>No</span><div class="switch"> <input type="hidden"
name='category_<?php echo $result['category_id'];?>_S4_Q5_q_waves' value="No" />
<input type="checkbox" class="cmn-toggle cmn-toggle-round sug-q-wave-2" value="Yes"
id='category_<?php echo $result['category_id'];?>_S4_Q5_q_waves'
name='category_<?php echo $result['category_id'];?>_S4_Q5_q_waves'> <label
class="checkbox-toggle" for="category_<?php echo
$result['category_id'];?>_S4_Q5_q_waves"></label></div> <span>Yes</span></div><div
class="reveal-if-active checkbox-block"><p class="full-width-line">Which leads have
<strong>abnormal Q waves?</strong></p><div class="checkbox-element"><p>V1:</p>
<input type="checkbox" value="V1" class="lead-checkbox sug-q-wave-v1"
id="category_<?php echo $result['category_id'];?>_checkbox_Q25"
name="category_<?php echo $result['category_id'];?>_S4_Q5_Q_waves_leads[]"/> <label
for="category_<?php echo $result['category_id'];?>_checkbox_Q25"></label></div><div
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class="checkbox-element"><p>V2:</p> <input type="checkbox" value="V2" class="lead-checkbox sug-q-wave-v2" id="category_<?php echo $result['category_id'];?>_checkbox_Q26" name="category_<?php echo $result['category_id'];?>_S4_Q5_Q_waves_leads[]" /> <label for="category_<?php echo $result['category_id'];?>_checkbox_Q26"></label></div><div class="checkbox-element"><p>V3:</p> <input type="checkbox" value="V3" class="lead-checkbox sug-q-wave-v3" id="category_<?php echo $result['category_id'];?>_checkbox_Q27" name="category_<?php echo $result['category_id'];?>_S4_Q5_Q_waves_leads[]" /> <label for="category_<?php echo $result['category_id'];?>_checkbox_Q27"></label></div><div class="checkbox-element"><p>V4:</p> <input type="checkbox" value="V4" class="lead-checkbox sug-q-wave-v4" id="category_<?php echo $result['category_id'];?>_checkbox_Q28" name="category_<?php echo $result['category_id'];?>_S4_Q5_Q_waves_leads[]" /> <label for="category_<?php echo $result['category_id'];?>_checkbox_Q28"></label></div><div class="checkbox-element"><p>V5:</p> <input type="checkbox" value="V5" class="lead-checkbox sug-q-wave-v5" id="category_<?php echo $result['category_id'];?>_checkbox_29" name="category_<?php echo $result['category_id'];?>_S4_Q5_Q_waves_leads[]" /> <label for="category_<?php echo $result['category_id'];?>_checkbox_29"></label></div><div class="checkbox-element"><p>V6:</p> <input type="checkbox" value="V6" class="lead-checkbox sug-q-wave-v6" id="category_<?php echo $result['category_id'];?>_checkbox_30" name="category_<?php echo $result['category_id'];?>_S4_Q5_Q_waves_leads[]" /> <label for="category_<?php echo $result['category_id'];?>_checkbox_30"></label></div></div></div><div class="question-block full-width mt-20"><p class="multi-line">Is there abnormal <strong>ST-segment elevation?</strong></p><div class="input-section"><span>No</span><div class="switch"> <input type="hidden" name='category_<?php echo $result['category_id'];?>_S4_Q6_st_el_wave' value="No" /> <input type="checkbox" class="cmn-toggle cmn-toggle-round sug-st-elevation-2" value="Yes" id='category_<?php echo $result['category_id'];?>_S4_Q6_st_el_wave' name='category_<?php echo $result['category_id'];?>_S4_Q6_st_el_wave'> <label class="checkbox-toggle" for="category_<?php echo $result['category_id'];?>_S4_Q6_st_el_wave"></label></div> <span>Yes</span></div><div class="reveal-if-active checkbox-block"><p class="full-width-line">Which leads have abnormal ST-segment elevation?</p><div class="checkbox-element"><p>V1:</p> <input type="checkbox" value="V1" class="lead-checkbox sug-st-elevation-v1" id="category_<?php echo $result['category_id'];?>_checkbox_31" name="category_<?php echo $result['category_id'];?>_S4_Q6_ST_elevation_leads[]"/> <label for="category_<?php echo $result['category_id'];?>_checkbox_31"></label></div><div class="checkbox-element"><p>V2:</p> <input type="checkbox" value="V2" class="lead-checkbox sug-st-elevation-v2" id="category_<?php echo $result['category_id'];?>_checkbox_32" name="category_<?php echo $result['category_id'];?>_S4_Q6_ST_elevation_leads[]" /> <label for="category_<?php echo $result['category_id'];?>_checkbox_32"></label></div><div class="checkbox-element"><p>V3:</p> <input type="checkbox" value="V3" class="lead-checkbox sug-st-elevation-v3" id="category_<?php echo $result['category_id'];?>_checkbox_33" name="category_<?php echo $result['category_id'];?>_S4_Q6_ST_elevation_leads[]" /> <label for="category_<?php echo $result['category_id'];?>_checkbox_33"></label></div><div class="checkbox-element"><p>V4:</p> <input type="checkbox" value="V4" class="lead-checkbox sug-st-
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elevation-v4" id="category_<?php echo $result['category_id'];?>_checkbox_34" name="category_<?php echo $result['category_id'];?>_S4_Q6_ST_elevation_leads[]" /> <label for="category_<?php echo $result['category_id'];?>_checkbox_34"></label></div><div class="checkbox-element"><p>V5:</p> <input type="checkbox" value="V5" class="lead-checkbox sug-st-elevation-v5" id="category_<?php echo $result['category_id'];?>_checkbox_Q35" name="category_<?php echo $result['category_id'];?>_S4_Q6_ST_elevation_leads[]" /> <label for="category_<?php echo $result['category_id'];?>_checkbox_Q35"></label></div><div class="checkbox-element"><p>V6:</p> <input type="checkbox" value="V6" class="lead-checkbox sug-st-elevation-v6" id="category_<?php echo $result['category_id'];?>_checkbox_Q36" name="category_<?php echo $result['category_id'];?>_S4_Q6_ST_elevation_leads[]" /> <label for="category_<?php echo $result['category_id'];?>_checkbox_Q36"></label></div></div></div><div class="question-block full-width mt-20"><p class="multi-line">Is there abnormal <strong>ST-segment depression?</strong></p><div class="input-section"> <span>No</span><div class="switch"> <input type="hidden" name='category_<?php echo $result['category_id'];?>_S4_Q7_ST_depression' value="No" /> <input type="checkbox" class="cmn-toggle cmn-toggle-round sug-st-depression-2" value="Yes" id='category_<?php echo $result['category_id'];?>_S4_Q7_ST_depression' name='category_<?php echo $result['category_id'];?>_S4_Q7_ST_depression'> <label class="checkbox-toggle" for="category_<?php echo $result['category_id'];?>_S4_Q7_ST_depression"></label></div> <span>Yes</span></div><div class="reveal-if-active checkbox-block"><p class="full-width-line">Which leads have abnormal ST-segment depression?</p><div class="checkbox-element"><p>V1:</p> <input type="checkbox" value="V1" class="lead-checkbox sug-st-depression-v1" id="category_<?php echo $result['category_id'];?>_checkbox_Q37" name="category_<?php echo $result['category_id'];?>_S4_Q7_ST_depression_leads[]"/> <label for="category_<?php echo $result['category_id'];?>_checkbox_Q37"></label></div><div class="checkbox-element"><p>V2:</p> <input type="checkbox" value="V2" class="lead-checkbox sug-st-depression-v2" id="category_<?php echo $result['category_id'];?>_checkbox_Q38" name="category_<?php echo $result['category_id'];?>_S4_Q7_ST_depression_leads[]" /> <label for="category_<?php echo $result['category_id'];?>_checkbox_Q38"></label></div><div class="checkbox-element"><p>V3:</p> <input type="checkbox" value="V3" class="lead-checkbox sug-st-depression-v3" id="category_<?php echo $result['category_id'];?>_checkbox_Q39" name="category_<?php echo $result['category_id'];?>_S4_Q7_ST_depression_leads[]" /> <label for="category_<?php echo $result['category_id'];?>_checkbox_Q39"></label></div><div class="checkbox-element"><p>V4:</p> <input type="checkbox" value="V4" class="lead-checkbox sug-st-depression-v4" id="category_<?php echo $result['category_id'];?>_checkbox_Q40" name="category_<?php echo $result['category_id'];?>_S4_Q7_ST_depression_leads[]" /> <label for="category_<?php echo $result['category_id'];?>_checkbox_Q40"></label></div><div class="checkbox-element"><p>V5:</p> <input type="checkbox" value="V5" class="lead-checkbox sug-st-depression-v5" id="category_<?php echo $result['category_id'];?>_checkbox_Q41" name="category_<?php echo $result['category_id'];?>_S4_Q7_ST_depression_leads[]" /> <label for="category_<?php echo $result['category_id'];?>_checkbox_Q41"></label></div><div class="checkbox-element"><p>V6:</p> <input type="checkbox" value="V6" class="lead-checkbox sug-st-depression-v6" id="category_<?php echo $result['category_id'];?>_checkbox_Q42"
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name="category_<?php echo $result['category_id'];?>_S4_Q7_ST_depression_leads[]" />
<label for="category_<?php echo
$result['category_id'];?>_checkbox_Q42"></label></div></div></div><div
class="question-block full-width mt-20"><p class="multi-line">Are there abnormal
<strong>T-waves?</strong></p><div class="input-section"> <span>No</span><div
class="switch"> <input type="hidden" name='category_<?php echo
$result['category_id'];?>_S4_Q8_T_wave' value="No" /> <input type="checkbox"
class="cmn-toggle cmn-toggle-round sug-t-wave-abnormal-2" value="Yes"
id='category_<?php echo $result['category_id'];?>_S4_Q8_T_wave'
name='category_<?php echo $result['category_id'];?>_S4_Q8_T_wave'> <label
class="checkbox-toggle" for="category_<?php echo
$result['category_id'];?>_S4_Q8_T_wave"></label></div> <span>Yes</span></div><div
class="reveal-if-active checkbox-block"><p class="full-width-line">Which leads have
abnormal <strong>T-waves?</strong></p><div class="checkbox-element"><p>V1:</p>
<input type="checkbox" value="V1" class="lead-checkbox sug-t-wave-abnormal-v1"
id="category_<?php echo $result['category_id'];?>_checkbox_Q43"
name="category_<?php echo $result['category_id'];?>_S4_Q8_T_waves_leads[]"/> <label
for="category_<?php echo $result['category_id'];?>_checkbox_Q43"></label></div><div
class="checkbox-element"><p>V2:</p> <input type="checkbox" value="V2" class="lead-
checkbox sug-t-wave-abnormal-v2" id="category_<?php echo
$result['category_id'];?>_checkbox_Q44" name="category_<?php echo
$result['category_id'];?>_S4_Q8_T_waves_leads[]" /> <label for="category_<?php echo
$result['category_id'];?>_checkbox_Q44"></label></div><div class="checkbox-
element"><p>V3:</p> <input type="checkbox" value="V3" class="lead-checkbox sug-t-
wave-abnormal-v3" id="category_<?php echo $result['category_id'];?>_checkbox_Q45"
name="category_<?php echo $result['category_id'];?>_S4_Q8_T_waves_leads[]" />
<label for="category_<?php echo
$result['category_id'];?>_checkbox_Q45"></label></div><div class="checkbox-
element"><p>V4:</p> <input type="checkbox" value="V4" class="lead-checkbox sug-t-
wave-abnormal-v4" id="category_<?php echo $result['category_id'];?>_checkbox_Q46"
name="category_<?php echo $result['category_id'];?>_S4_Q8_T_waves_leads[]" />
<label for="category_<?php echo
$result['category_id'];?>_checkbox_Q46"></label></div><div class="checkbox-
element"><p>V5:</p> <input type="checkbox" value="V5" class="lead-checkbox sug-t-
wave-abnormal-v5" id="category_<?php echo $result['category_id'];?>_checkbox_Q47"
name="category_<?php echo $result['category_id'];?>_S4_Q8_T_waves_leads[]" />
<label for="category_<?php echo
$result['category_id'];?>_checkbox_Q47"></label></div><div class="checkbox-
element"><p>V6:</p> <input type="checkbox" value="V6" class="lead-checkbox sug-t-
wave-abnormal-v6" id="category_<?php echo $result['category_id'];?>_checkbox_Q48"
name="category_<?php echo $result['category_id'];?>_S4_Q8_T_waves_leads[]" />
<label for="category_<?php echo
$result['category_id'];?>_checkbox_Q48"></label></div></div></div></div></div>
<input type="hidden" id='category_<?php echo $result['category_id'];?>_S4_time_end'
name="category_<?php echo $result['category_id'];?>_S4_time_end"></input></div><div
class="footer"> <button id='<?php echo $i;?>' class='previous btn btn-success'
type='button' onclick="this.value= '+' + ((new Date() -
date_start)/1000).toString()">Previous</button><h3 class="place-description">Part
4/5</h3> <button id='<?php echo $i;?>' class='next btn btn-success' type='button'
onclick="getElementById('category_<?php echo
$result['category_id'];?>_S4_time_end').value= '+' + ((new Date() -
date_start)/1000).toString(); this.value= '+' + ((new Date() -
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date_start)/1000).toString()">Next</button> <input type="hidden" value="<?php echo
$i;?>" class="ecg-part"></div></div> <?php }elseif($i==5 || $i==10 || $i==15 ||
$i==20 ){?><div id='question<?php echo $i;?>' class='cont'> <section class="img-
block scale"> <img title="12-lead" class="large-image" src="<?php echo
$result['ECG_image'];?>" /> <input type="hidden" value="<?php echo $i;?>"
class="image-page-number"> </section><div class="section-title">Prompt: Interpret
the entire 12-lead ECG</div><div class="container"><div class="content-section"><h4
class="headings">Questions:</h4><div class="question-block"><p class="multi-
line">Is the R-wave progression abnormal?</p><div class="input-section">
<span>No</span><div class="switch"> <input type="hidden" name="category_<?php echo
$result['category_id'];?>_S5_Q1_R_wave" value="No" /> <input type="checkbox"
class="cmn-toggle cmn-toggle-round sug-r-progress" value="Yes" id='category_<?php
echo $result['category_id'];?>_S5_Q1_R_wave' name='category_<?php echo
$result['category_id'];?>_S5_Q1_R_wave' > <label for="category_<?php echo
$result['category_id'];?>_S5_Q1_R_wave"></label></div>
<span>Yes</span></div></div><div class="question-block"><p class="multi-line">Is
there suspected chest lead misplacement?</p><div class="input-section">
<span>No</span><div class="switch"> <input type="hidden" name="category_<?php echo
$result['category_id'];?>_S5_Q2_chest_lead" value="No" /> <input type="checkbox"
class="cmn-toggle cmn-toggle-round sug-chest-misplacement" value="Yes"
id='category_<?php echo $result['category_id'];?>_S5_Q2_chest_lead'
name='category_<?php echo $result['category_id'];?>_S5_Q2_chest_lead' > <label
for="category_<?php echo $result['category_id'];?>_S5_Q2_chest_lead"></label></div>
<span>Yes</span></div></div><div class="question-block"><p class="multi-line">Is
there suspected limb lead misplacement?</p><div class="input-section">
<span>No</span><div class="switch"> <input type="hidden" name="category_<?php echo
$result['category_id'];?>_S5_Q3_limb_lead" value="No" /> <input type="checkbox"
class="cmn-toggle cmn-toggle-round sug-limb-misplacement" value="Yes"
id='category_<?php echo $result['category_id'];?>_S5_Q3_limb_lead'
name='category_<?php echo $result['category_id'];?>_S5_Q3_limb_lead' > <label
for="category_<?php echo $result['category_id'];?>_S5_Q3_limb_lead"></label></div>
<span>Yes</span></div></div><hr class="clear"><div class="question-block full-
width"><h4 class="headings centre mb-10">Suggested ECG intepretations</h4><h5
class="headings centre mb-20 ">These suggestions are based on your personal
annotations of this ECG</h5><div class="suggestion-box"><div
class="suggestions"><table><thead><tr><th>Diagnosis</th><th>Criteria met <i
class="fa fa-sort" aria-hidden="true"></i></th><th>Notes</th><th>View
criteria</th></tr></thead><tbody><tr><td>No diagnosis
available</td><td>##</td><td>##</td><td>##</td></tr></tbody></table></div></div></
div> <input type="hidden" id='category_<?php echo
$result['category_id'];?>_S5_suggestions' name="category_<?php echo
$result['category_id'];?>_S5_suggestions" class="suggestion_gathering"><hr
class="clear"><div class="question-block full-width"><h4 class="headings mb-20
clear">Final Interpretation / Diagnosis:</h4><div id="autocomplete-outer" class="ui-
helper-clearfix auto-div"><div> <input type="text" required id='category_<?php echo
$result['category_id'];?>_diagnosis' name='category_<?php echo
$result['category_id'];?>_S5_diagnosis' class="final_answer unused-suggestion-
elements"/></div></div></div> <input type="hidden" id='category_<?php echo
$result['category_id'];?>_S5_time_end' name="category_<?php echo
$result['category_id'];?>_S5_time_end"> <input type="hidden" id='category_<?php
echo $result['category_id'];?>_next_S1_time_start' name="category_<?php echo
$result['category_id'];?>_next_S1_time_start"></div></div><div class="footer">
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<button id='<?php echo $i;?>' class='previous btn btn-success' type='button'
onclick="this.value= '+' + ((new Date() -
date_start)/1000).toString()">Previous</button><h3 class="place-description">Part
5/5</h3> <button id='dialog_<?php echo $i;?>_button' class='next btn btn-success'
type='button' onclick="getElementById('category_<?php echo
$result['category_id'];?>_S5_time_end').value= '+' + ((new Date() -
date_start)/1000).toString(); this.value= '+' + ((new Date() -
date_start)/1000).toString()">Next</button><div id="confidence_modal_<?php echo
$result['category_id'];?>" class="confidence-modal"><div class="rating"> <label
for='category_<?php echo
$result['category_id'];?>_conf_level'>Confidence</label><p>Please rate your self-
confidence in your final diagnosis</p> <input type='range' min='0' max='10' value='5'
id='category_<?php echo $result['category_id'];?>_conf_level' name='category_<?php
echo $result['category_id'];?>_conf_level' step='1' class="conf_level range-input-
category-<?php echo $result['category_id'];?> unused-suggestion-elements"
list='levelsettings' oninput="outputUpdate('value', this)"
onchange="rangeUpdate('value', this)"> <span class="rating-explained
low">Low</span><span class="rating-explained high">High</span> <output
for='category_<?php echo $result['category_id'];?>_conf_level' id='category_<?php
echo $result['category_id'];?>_conf_level_output'>5</output><span
class="output">/10</span></div> <button id='next_<?php echo $i;?>' class='next
finish-confidence btn btn-success' type='button'
onclick="getElementById('category_<?php echo
$result['category_id'];?>_next_S1_time_start').value= '+' + ((new Date() -
date_start)/1000).toString()">Move to ECG <span class="page-number"> <?php echo
$result['category_id']+1;?>/10</button></div> <input type="hidden" value="<?php
echo $i;?>" class="ecg-part"> <script>$(function(){$("#confidence_modal_<?php echo
$result['category_id'];?>").dialog({autoOpen:false,modal:true,resizable:false,appe
ndTo:"#question<?php echo $i;?>"});$('#dialog_<?php echo
$i;?>_button').click(function(){var
form=$("#questions");form.validate({focusInvalid:false,invalidHandler:function(for
m,validator){if(!validator.numberOfInvalids()) return;$('html,
body').animate({scrollTop:$(validator.errorList[0].element).offset().top},2000);},
tooltip_options:{'_all_':{placement:'bottom'}}});if(form.valid()){var
next_button=$(this).val();var page_number=$(this).siblings().children(".page-
number").text();var part_number=$(this).siblings(".ecg-
part").val();part_number=part_number+'/50';var page_and_place=part_number+' -
'+page_number;var
dataString='next_button='+next_button+'&page_number='+page_and_place;$.ajax({data:
dataString,type:"post",url:"insert_button_press.php"});$.ui.dialog.prototype._focu
sTabbable=function(){};$("#confidence_modal_<?php echo
$result['category_id'];?>").dialog('open');return false;}});$('#next_<?php echo
$i;?>').click(function(){last=<?php echo
$i;?>;nex=last+1;$('#question'+last).parent().hide("slide",{direction:"up"},200).c
ss("height","0%");$('#question'+nex).parent().css("height","100%");$('#question'+n
ex).delay(200).show("slide",{direction:"down"},200);$('.range-input-category-
'+(<?php echo $result['category_id'];?>)).each(function(){var
input_element=$(this);var input_value=$(this).val();var
default_input_value=input_element.prop('defaultValue');if(input_value==default_inp
ut_value){input_element.prop("type","text");input_element.prop("value","NC");}else
{console.log("nope");}});var answer_array=[];$("#section_ending_<?php echo $i;?>
.final_answer").parent().siblings('span').each(function(){answer_array.push($(this
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)[0].childNodes[0].nodeValue.trim());});answer_array.push($("#section_ending_<?php echo $i;?> .final_answer").val());$("#section_ending_<?php echo $i;?> .final_answer").val(answer_array);var fields=$("#section_ending_<?php echo $i;?> :input").serialize();$.ajax({data:fields,type:"post",url:"insert_ECG_results.php"});$("#confidence_modal_<?php echo $result['category_id'];?>").dialog('close');return false;});});</script>
</div></div></div><?php }elseif($i==25 ){?><div id='question<?php echo $i;?>' class='cont'> <section class="img-block scale"> <img title="Limb leads" src="<?php echo $result['ECG_image'];?>" /> <input type="hidden" value="<?php echo $i;?>" class="image-page-number"> </section><div class="section-title">Prompt: Interpret the entire 12-lead ECG</div><div class="container"><div class="content-section"><h4 class="headings">Questions:</h4><div class="question-block"><p>Is the R-wave progression normal?</p><div class="input-section"> <span>No</span><div class="switch"> <input type="hidden" name="category_<?php echo $result['category_id'];?>_S5_Q1_R_wave" value="No" /> <input type="checkbox" class="cmn-toggle cmn-toggle-round" value="Yes" id='category_<?php echo $result['category_id'];?>_S5_Q1_R_wave' name='category_<?php echo $result['category_id'];?>_S5_Q1_R_wave' > <label for="category_<?php echo $result['category_id'];?>_S5_Q1_R_wave"></label></div>
<span>Yes</span></div></div><div class="question-block"><p>Is there suspected chest lead misplacement?</p><div class="input-section"> <span>No</span><div class="switch"> <input type="hidden" name="category_<?php echo $result['category_id'];?>_S5_Q2_chest_lead" value="No" /> <input type="checkbox" class="cmn-toggle cmn-toggle-round" value="Yes" id='category_<?php echo $result['category_id'];?>_S5_Q2_chest_lead' name='category_<?php echo $result['category_id'];?>_S5_Q2_chest_lead' > <label for="category_<?php echo $result['category_id'];?>_S5_Q2_chest_lead"></label></div>
<span>Yes</span></div></div><div class="question-block"><p>Is there suspected limb lead misplacement?</p><div class="input-section"> <span>No</span><div class="switch"> <input type="hidden" name="category_<?php echo $result['category_id'];?>_S5_Q3_limb_lead" value="No" /> <input type="checkbox" class="cmn-toggle cmn-toggle-round" value="Yes" id='category_<?php echo $result['category_id'];?>_S5_Q3_limb_lead' name='category_<?php echo $result['category_id'];?>_S5_Q3_limb_lead' > <label for="category_<?php echo $result['category_id'];?>_S5_Q3_limb_lead"></label></div>
<span>Yes</span></div></div><hr class="clear"><div class="question-block full-width"><h4 class="headings centre mb-10">Suggested ECG intepretations</h4><h5 class="headings centre mb-20 ">These suggestions are based on your personal annotations of this ECG</h5><div class="suggestion-box"><div class="suggestions"><table><thead><tr><th>Diagnosis</th><th>Criteria met <i class="fa fa-sort" aria-hidden="true"></i></th><th>Notes</th><th>View criteria</th></tr></thead><tbody><tr><td>No diagnosis available</td><td>##</td><td>##</td><td>##</td></tr></tbody></table></div></div></div> <input type="hidden" id='category_<?php echo $result['category_id'];?>_S5_suggestions' name="category_<?php echo $result['category_id'];?>_S5_suggestions" class="suggestion_gathering"><hr class="clear"><div class="question-block full-width"><h4 class="headings mb-20 clear">Final Interpretation / Diagnosis:</h4><div id="autocomplete-outer" class="ui-helper-clearfix auto-div"><div> <input type="text" required id='category_<?php echo $result['category_id'];?>_diagnosis' name='category_<?php echo $result['category_id'];?>_S5_diagnosis' class="final_answer unused-suggestion-elements"/></div></div></div> <input type="hidden" id='category_<?php echo
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$result['category_id'];?>_S5_time_end' name="category_<?php echo $result['category_id'];?>_S5_time_end"></input></div></div><div class="footer"> <button id='<?php echo $i;?>' class='previous btn btn-success' type='button' onclick="this.value= '+' + ((new Date() - date_start)/1000).toString()">Previous</button><h3 class="place-description">Part 5/5</h3> <button id='dialog_<?php echo $i;?>_button' class='next btn btn-success' type='button' onclick="getElementById('category_<?php echo $result['category_id'];?>_S5_time_end').value= '+' + ((new Date() - date_start)/1000).toString(); this.value= '+' + ((new Date() - date_start)/1000).toString()">Next</button><div id="confidence_modal_<?php echo $result['category_id'];?>" class="confidence-modal"><div class="rating"> <label for='category_<?php echo $result['category_id'];?>_conf_level'>Confidence</label><p>Please rate your self-confidence in your final diagnosis</p> <input type='range' min='0' max='10' value='5' id='category_<?php echo $result['category_id'];?>_conf_level' name='category_<?php echo $result['category_id'];?>_conf_level' step='1' class="conf_level range-input-category-<?php echo $result['category_id'];?> unused-suggestion-elements" list='levelsettings' oninput="outputUpdate('value', this)" onchange="outputUpdate('value', this)"> <span class="rating-explained low">Low</span><span class="rating-explained high">High</span> <output for='category_<?php echo $result['category_id'];?>_conf_level' id='category_<?php echo $result['category_id'];?>_conf_level_output'>5</output><span class="output">/10</span></div></div> <input type="hidden" value="<?php echo $i;?>" class="ecg-part"> <script>$(function(){$("#confidence_modal_<?php echo $result['category_id'];?>").dialog({autoOpen:false,modal:true,resizable:false,appendTo:"#question<?php echo $i;?>",buttons:[{text:"Finish",class:"next_<?php echo $i;?> finish-confidence btn btn-success",click:function(){update_range();submit_form();}}]});$('#dialog_<?php echo $i;?>_button').click(function(){var answer_array=[];$("#section_ending_<?php echo $i;?> .final_answer").parent().siblings('span').each(function(){answer_array.push($(this)[0].childNodes[0].nodeValue.trim());});answer_array.push($("#section_ending_<?php echo $i;?> .final_answer").val());$("#section_ending_<?php echo $i;?> .final_answer").val(answer_array);var form=$("#questions");form.validate({focusInvalid:false,invalidHandler:function(form,validator){if(!validator.numberOfInvalids()) return;$('html, body').animate({scrollTop:$(validator.errorList[0].element).offset().top},2000);}, tooltip_options:{'_all_':{placement:'bottom'}}});if(form.valid()){var next_button=$(this).val();var page_number=$(this).siblings().children(".page-number").text();var part_number=$(this).siblings(".ecg-part").val();part_number=part_number+'/50';var page_and_place=part_number+' - '+page_number;var dataString='next_button='+next_button+'&page_number='+page_and_place;$.ajax({data: dataString,type:"post",url:"insert_button_press.php"});$.ui.dialog.prototype._focusTabbable=function(){};$("#confidence_modal_<?php echo $result['category_id'];?>").dialog('open');return false;}});$('#next_<?php echo $i;?>').click(function(){last=<?php echo $i;?>;nex=last+1;$('#question'+last).parent().hide("slide",{direction:"up"},200).css("height","0%");$('#question'+nex).parent().css("height","100%");$('#question'+nex).delay(200).show("slide",{direction:"down"},200);$("#confidence_modal_<?php echo $result['category_id'];?>").dialog('close');return false;});});</script> </div></div></div><?php } $i++;} ?></form>
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<script>jQuery.extend(jQuery.validator.messages,{required:"Please fill in this field before continuing.",});</script>
<script>$('.cont').hide();count=$('.questions').length;$('#question'+1).show();$(document).on('click','.next',function(){var form=$("#questions");var next_button=$(this).val();var page_number=$(this).siblings().children(".page-number").text();var part_number=$(this).siblings(".ecg-part").val();part_number=part_number+'/50';var page_and_place=part_number+' - '+page_number;var dataString='next_button='+next_button+'&page_number='+page_and_place;$.ajax({data:dataString,type:"post",url:"insert_button_press.php"});last=parseInt($(this).attr('id'));nex=last+1;$('#question'+last).hide("slide",{direction:"up"},200).css("height","0%");$('#question'+nex).css("height","100%");$('#question'+nex).delay(200).show("slide",{direction:"down"},200);$("body").scrollTop(0);});$(document).on('click','.previous',function(){var previous_button=$(this).val();var page_number=$(this).siblings().children(".page-number").text();var part_number=$(this).siblings(".ecg-part").val();part_number=part_number+'/50';var page_and_place=part_number+' - '+page_number;var dataString='previous_button='+previous_button+'&page_number='+page_and_place;$.ajax({data:dataString,type:"post",url:"insert_button_press.php"});last=parseInt($(this).attr('id'));pre=last-1;$('#question'+last).hide("slide",{direction:"down"},200);$('#question'+pre).delay(100).show("slide",{direction:"up"},200);});$(document).on('click touchstart','img',function(e){var image_press='Pressed';var previous_button='Not pressed';var next_button='Not pressed';var page_number=$(this).siblings('.image-page-number').val()+'/50';var dataString='previous_button='+previous_button+'&page_number='+page_number+'&image_press='+image_press;$.ajax({data:dataString,type:"post",url:"insert_button_press.php"});});$(document).ready(function(){$('input[type=number]').bind("input",function(){if(this.value.length>10) this.value=this.value.slice(0,10);})
$('input[type=text]').bind("paste",function(e){e.preventDefault();});$('input[type=number]').bind("paste",function(e){e.preventDefault();});});</script>
<script>$(document).ready(function(){$('.reveal-if-active').hide();$(".p-wave-toggle").click(function(){$(this).parent().parent().parent().siblings(".active-reveal").slideToggle(800,"easeInOutExpo");$(this).parent().parent().parent().siblings(".reveal-if-active").slideToggle(800,"easeInOutExpo",function(){$('html, body').animate({scrollTop:$(document).height()},'slow');return false;});});$(".checkbox-toggle").click(function(){$(this).parent().parent().siblings(".reveal-if-active").slideToggle(800,"easeInOutExpo");});});</script>
<script>$(document).ready(function(){$('input[type=text]').bind("paste",function(e){e.preventDefault();});$('input[type=number]').bind("paste",function(e){e.preventDefault();});});</script> </body></html> <?php }else{ header( 'Location: http://localhost/~AndrewCairns/Rule-based%20ECG%20interpretation/experimental/' ) ; } ?>
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main.js
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// Prevents back swipe and button by adding alert question $(window).bind('beforeunload', function() { return "Are you sure? Your work will be lost!"; });function update_range(){ $("#questions").validate().cancelSubmit = true; // Fix for unchanged range elements to default answers to NC $('.range-input-category-5' ).each(function() { console.log() var input_element = $(this);
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console.log(input_element); var input_value = $(this).val(); var default_input_value
= input_element.prop('defaultValue');if ( input_value == default_input_value ) {
input_element.prop("type", "text"); input_element.prop("value", "NC"); } else {
console.log("nope"); }console.log(input_element);});};// Form Submit function
submit_form(){ $(window).unbind('beforeunload'); $('#questions').submit();
};//loading gif $(window).load(function() { $('#loading').hide(); });//confidence
slider update function outputUpdate(vol, el) { var conf_level_id = el.id; var
conf_level_value = el.value;$('#' + conf_level_id +
'_output').html(conf_level_value); var value = conf_level_value/10;
document.querySelector('#' + conf_level_id).style.backgroundImage = [ '-webkit-
gradient(', 'linear, ', 'left top, ', 'right top, ', 'color-stop(' + value + ',
#ff6861), ', 'color-stop(' + value + ', rgba(0,0,0,0))', ')' ].join(''); };//range
slider updates function rangeUpdate(vol, el) { var range_level_id = el.id; var
range_level_value = el.value; var max = el.max;$('#' + range_level_id +
'_output').html(range_level_value); var value = range_level_value/max;
document.querySelector('#' + range_level_id).style.backgroundImage = [ '-webkit-
gradient(', 'linear, ', 'left top, ', 'right top, ', 'color-stop(' + value + ',
#ff6861), ', 'color-stop(' + value + ', rgba(0,0,0,0))', ')' ].join(''); };function
isNumberKey(evt){ var charCode = (evt.which) ? evt.which : event.keyCode if (charCode
> 31 && (charCode != 46 &&(charCode < 48 || charCode > 57))) return false; return
true; };function split( val ) { return val.split( / s*/ ); } function extractLast(
term ) { return split( term ).pop(); }$(document).ready(function(){ $(".axis-
indication").roundSlider({ sliderType: "min-range", radius: 180, value: 0, width: 0,
max: 180, min: -180, handleSize: 0, handleShape: "square", circleShape: "full" });var
amp, dur; $('.pwave-result').hide(); $(".p-wave").on("change", function() { if (
$(this).hasClass("p-wave-dur")){ dur = $(this).val(); } else if (
$(this).hasClass("p-wave-amp")){ amp = $(this).val(); }if (dur == '' || dur ==
undefined || amp == '' || amp == undefined) { $(this).parent().siblings('.pwave-
result').hide(); } else { $(this).parent().siblings('.pwave-result').slideDown(500,
"easeInExpo"); }if (amp > 2.5 && dur <= 0.12) { $(this).parent().siblings('.pwave-
result').fadeOut("fast",function(){ $(this).html('Your measurements indicate
<strong>Right Atrial Enlargement</strong>') }).fadeIn("fast"); }else if (dur > 0.12
&& amp <= 2.5) { $(this).parent().siblings('.pwave-
result').fadeOut("fast",function(){ $(this).html('Your measurements indicate
<strong>Left Atrial Enlargement</strong>') }).fadeIn("fast"); }else if (dur > 0.12
&& amp > 2.5 ) { $(this).parent().siblings('.pwave-
result').fadeOut("fast",function(){ $(this).html('Your measurements indicate
<strong>Bi-Atrial Atrial Enlargement</strong>') }).fadeIn("fast"); }else if (dur <=
0.12 && amp <= 2.5 ) { $(this).parent().siblings('.pwave-
result').fadeOut("fast",function(){ $(this).html('Your measurements indicate
<strong>No Atrial Enlargement</strong>') }).fadeIn("fast"); }; });// $(".axis-
result").hide(); $("body").on('DOMSubtreeModified', "span.axis-indication",
function () { var axis_value = $(this).html();if (axis_value >= -30 && axis_value <=
90 ) { $(this).parent().parent().siblings('.axis-result').html('Measurement is
<strong><span>normal</span></strong>'); }else if (axis_value < -30 && axis_value >=
-90 ) { $(this).parent().parent().siblings('.axis-result').html('Measurement
highlights <strong><span>LAD</span></strong>'); }else if (axis_value > 90 &&
axis_value <= 180) { $(this).parent().parent().siblings('.axis-
result').html('Measurement highlights <strong><span>RAD</span></strong>'); }else if
(axis_value < -90 && axis_value >= -180) {
$(this).parent().parent().siblings('.axis-result').html('Measurement highlights
<strong><span>Extreme RAD</span></strong>'); }else {
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$(this).parent().parent().siblings('.axis-result').html('Measurement is invalid');
}; });var rr_dur = 0, qt_dur = 0; $('.QTc-element').hide(); $(".qtc-calc").on("input
change", function() { if ( $(this).hasClass("qt-duration")){ qt_dur = $(this).val();
} else if ( $(this).hasClass("rr-duration")){ rr_dur = $(this).val(); } var QTc_value
= " " + parseFloat(qt_dur / Math.sqrt(rr_dur)).toFixed(2); if ( QTc_value ==
Infinity){ QTc_value = "Adjust the R-R interval"
$(this).parent().siblings('div').children(".QTc-output").css({ 'font-size' :
'0.8em','color' : 'white', 'width':'145px'}).val(QTc_value); } else if (QTc_value ==
0.00){ QTc_value = "Adjust the QT interval"
$(this).parent().siblings('div').children(".QTc-output").css({ 'font-size' :
'0.8em','color' : 'white', 'width':'145px'}).val(QTc_value); } else {
$(this).parent().siblings('div').children(".QTc-output").css({ 'font-size' :
'2em','color' : 'white', 'width':'145px'}).val(QTc_value); }
$(this).parent().siblings('.QTc-element').show("slide", { direction: "up" },
200);});//Sort table function function OrderBy(a,b,n) { if (n) return (a-b); if (a
< b) return (-1); if (a > b) return (1); return 0; } $('th').click(function() { if
(!$(this).attr('data-toggled') || $(this).attr('data-toggled') == 'asc') {
$(this).attr('data-toggled','desc'); if($(this).children('i').is('.fa-sort, .fa-
sort-desc')) { $(this).children('i').removeClass("fa-sort fa-sort-desc");
$(this).children('i').addClass("fa-sort-asc"); }
if($(this).siblings().children('i').is('.fa-sort-desc, .fa-sort-asc')) {
$(this).siblings().children('i').removeClass("fa-sort-desc fa-sort-asc");
$(this).siblings().children('i').addClass("fa-sort"); } } else if
($(this).attr('data-toggled') == 'desc') { $(this).attr('data-toggled','asc');
if($(this).children('i').is('.fa-sort, .fa-sort-asc')) {
$(this).children('i').removeClass("fa-sort fa-sort-asc");
$(this).children('i').addClass("fa-sort-desc"); }
if($(this).siblings().children('i').is('.fa-sort-desc, .fa-sort-asc')) {
$(this).siblings().children('i').removeClass("fa-sort-desc fa-sort-asc");
$(this).siblings().children('i').addClass("fa-sort"); } };var $th =
$(this).closest('th'); $th.toggleClass('selected'); var isSelected =
$th.hasClass('selected'); var isInput= $th.hasClass('input'); var column =
$th.index(); var $table = $th.closest('table'); var isNum= $table.find('tbody >
tr').children('td').eq(column).hasClass('num'); var rows = $table.find('tbody >
tr').get(); rows.sort(function(rowA,rowB) { if (isInput) { var keyA =
$(rowA).children('td').eq(column).children('input').val().toUpperCase(); var keyB =
$(rowB).children('td').eq(column).children('input').val().toUpperCase(); } else {
var keyA = parseInt( $(rowA).children('td').eq(column).text().toUpperCase() ); var
keyB = parseInt( $(rowB).children('td').eq(column).text().toUpperCase() ); } if
(isSelected) return OrderBy(keyA,keyB,isNum); return OrderBy(keyB,keyA,isNum); });
$.each(rows, function(index,row) { $table.children('tbody').append(row); }); return
false; });$.getJSON("json/ECG_individual_default_criteria.json", function (data) {
clients=data; var clients_ar=[]; $.each(data, function(k,v) { var client=[];
client['value']=v.name; clients_ar.push(client);
});$('.final_answer').autocomplete({ source: clients_ar, minLength: 1, position: {
my: "left bottom", at: "left top", collision: "flip" }, select: function(e, ui) {
//create formatted friend var friend = ui.item.value; var span =
$("<span>").text(friend); var a = $("<a>").addClass("remove").attr({ href:
"javascript:", title: "Remove " + friend }).text("x").appendTo(span); //add friend
to friend div span.insertBefore( $(this).closest("div")) ; this.value =
"";//removing the input required attr as fixes validation on input
$(this).removeAttr('required'); return false;} }); });});
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$(document).ready(function(){  //add  click  handler  to  autocomplete-outer  div
$(".auto-div").click(function(){  $(this).find(".final_answer").focus();  });  //add
live  handler  for  clicks  on  remove  links  $(document).on("click",  ".remove",
function(){ //remove current friend $(this).parent().remove(); //correct 'to' field
position      if($("#autocomplete-outer      span").length      ===      0)      {
$(this).parent().css("top", 0); } }); });
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Algorithm.js
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$(document).ready(function(){$("input").not('.unused-suggestion-
elements').on('change', function(){ var suggestion_output = $(".suggestions table
tbody").empty(); var category = $(this).closest("div.outer-element");// Collection
and  formatting  statements  var  regular_rhythm  =  (  $('.sug-regular-rhythm',
category).is(':checked')  )  ?  'regular'  :  'irregular';  var  HR  =  ($('.sug-HR',
category).val() < 60 ) ? 'slow' : ($('.sug-HR').val() > 100 ) ? 'rapid' : 'normal';
var  P_QRS_association  =  ($('.sug-P-QRS-association',  category).is(':checked'))  ?
'yes'  :  'no';  var  sinus  =  ($('.sug-sinus',  category).is(':checked'))  ?  'yes'  :
'no';var  p_wave  =  ($('.sug-P-wave-present',  category).is(':checked'))  ?  'yes'  :
'no'; var p_wave_type = ($('.sug-p-wave-type', category).is(':checked')) ? $('.sug-
p-wave-type:checked', category).val() : 'none'; var p_wave_dur = ($('.sug-p-wave-
dur', category).val() <= 0.12 ) ? 'normal' : 'large'; var p_wave_amp = ($('.sug-p-
wave-amp', category).val() <= 2.5 ) ? 'normal' : 'large'; var pr_interval_varying =
($('.sug-PR-interval-variation',  category).is(':checked'))  ?  'yes'  :  'no';  var
pr_interval = ($('.sug-pr-interval', category).val() < 0.12 ) ? 'narrow' : ($('.sug-
pr-interval').val()  >  0.2  )  ?  'broad'  :  'normal';var qrs_axis = $('.axis-result
span', category).html(); var qrs_axis_value = ( qrs_axis == 'LAD' ) ? 'LAD' : (
qrs_axis == 'RAD' ) ? 'RAD' : (qrs_axis == 'Extreme RAD' ) ? 'Extreme RAD' : 'normal
deviation'; var q_wave = ($('.sug-q-wave-1', category).is(':checked') || $('.sug-q-
wave-2', category).is(':checked')) ? 'yes' : 'no'; var q_wave_v1 = ($('.sug-q-wave-
v1', category).is(':checked')) ? 'yes' : 'no'; var q_wave_v2 = ($('.sug-q-wave-v2',
category).is(':checked'))  ?  'yes'  :  'no';  var  q_wave_v3  =  ($('.sug-q-wave-v3',
category).is(':checked'))  ?  'yes'  :  'no';  var  q_wave_v4  =  ($('.sug-q-wave-v4',
category).is(':checked'))  ?  'yes'  :  'no';  var  q_wave_v5  =  ($('.sug-q-wave-v5',
category).is(':checked'))  ?  'yes'  :  'no';  var  q_wave_v6  =  ($('.sug-q-wave-v6',
category).is(':checked'))  ?  'yes'  :  'no';  var  q_wave_I  =  ($('.sug-q-wave-I',
category).is(':checked'))  ?  'yes'  :  'no';  var  q_wave_II  =  ($('.sug-q-wave-II',
category).is(':checked')) ? 'yes' : 'no'; var q_wave_III = ($('.sug-q-wave-III',
category).is(':checked')) ? 'yes' : 'no'; var q_wave_aVR = ($('.sug-q-wave-aVR',
category).is(':checked')) ? 'yes' : 'no'; var q_wave_aVL = ($('.sug-q-wave-aVL',
category).is(':checked')) ? 'yes' : 'no'; var q_wave_aVF = ($('.sug-q-wave-aVF',
category).is(':checked'))   ?   'yes'   :   'no';if   (   $('.sug-st-elevation-1',
category).is(':checked') || $('.sug-st-elevation-2', category).is(':checked') ) {
var  ST_elevation  =  "yes";  }else  {  var  ST_elevation  =  "no";  };if  (  $('.sug-st-
elevation-v1',      category).is(':checked')      &&      $('.sug-st-elevation-v2',
category).is(':checked')  )  {var  ST_elevation_septal  =  "yes";  }  else  {  var
ST_elevation_septal      =      "no";      };if      (      $('.sug-st-elevation-v3',
category).is(':checked')  &&  $('.sug-st-elevation-v4',  category).is(':checked')  )
{var ST_elevation_anterior = "yes"; } else { var ST_elevation_anterior = "no"; };if
( ( $('.sug-st-elevation-II', category).is(':checked') && $('.sug-st-elevation-III',
category).is(':checked') ) || ( $('.sug-st-elevation-II', category).is(':checked')
&& $('.sug-st-elevation-aVF', category).is(':checked') ) || ( $('.sug-st-elevation-
III',        category).is(':checked')        &&        $('.sug-st-elevation-aVF',
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category).is(':checked')) ) { var ST_elevation_inferior = "yes"; } else { var ST_elevation_inferior = "no"; };if ( ( $('.sug-st-elevation-v5', category).is(':checked') && $('.sug-st-elevation-v6', category).is(':checked') ) || ( $('.sug-st-elevation-v5', category).is(':checked') && $('.sug-st-elevation-I', category).is(':checked') ) || ( $('.sug-st-elevation-v5', category).is(':checked') && $('.sug-st-elevation-aVL', category).is(':checked') ) || ( $('.sug-st-elevation-v6', category).is(':checked') && $('.sug-st-elevation-I', category).is(':checked') ) || ( $('.sug-st-elevation-v6', category).is(':checked') && $('.sug-st-elevation-aVL', category).is(':checked') ) || ( $('.sug-st-elevation-I', category).is(':checked') && $('.sug-st-elevation-aVL', category).is(':checked')) ) { var ST_elevation_lateral = "yes"; } else { var ST_elevation_lateral = "no"; };// var ST_elevation = ($('.sug-st-elevation-1', category).is(':checked') || $('.sug-st-elevation-2', category).is(':checked')) ? 'yes' : 'no'; // var ST_elevation_v1 = ($('.sug-st-elevation-v1', category).is(':checked')) ? 'yes' : 'no'; // var ST_elevation_v2 = ($('.sug-st-elevation-v2', category).is(':checked')) ? 'yes' : 'no'; // var ST_elevation_v3 = ($('.sug-st-elevation-v3', category).is(':checked')) ? 'yes' : 'no'; // var ST_elevation_v4 = ($('.sug-st-elevation-v4', category).is(':checked')) ? 'yes' : 'no'; // var ST_elevation_v5 = ($('.sug-st-elevation-v5', category).is(':checked')) ? 'yes' : 'no'; // var ST_elevation_v6 = ($('.sug-st-elevation-v6', category).is(':checked')) ? 'yes' : 'no'; // var ST_elevation_I = ($('.sug-st-elevation-I', category).is(':checked')) ? 'yes' : 'no'; // var ST_elevation_II = ($('.sug-st-elevation-II', category).is(':checked')) ? 'yes' : 'no'; // var ST_elevation_III = ($('.sug-st-elevation-III', category).is(':checked')) ? 'yes' : 'no'; // var ST_elevation_aVR = ($('.sug-st-elevation-aVR', category).is(':checked')) ? 'yes' : 'no'; // var ST_elevation_aVL = ($('.sug-st-elevation-aVL', category).is(':checked')) ? 'yes' : 'no'; // var ST_elevation_aVF = ($('.sug-st-elevation-aVF', category).is(':checked')) ? 'yes' : 'no'; var ST_depression = ($('.sug-st-depression-1', category).is(':checked') || $('.sug-st-depression-2', category).is(':checked')) ? 'yes' : 'no'; var ST_depression_v1 = ($('.sug-st-depression-v1', category).is(':checked')) ? 'yes' : 'no'; var ST_depression_v2 = ($('.sug-st-depression-v2', category).is(':checked')) ? 'yes' : 'no'; var ST_depression_v3 = ($('.sug-st-depression-v3', category).is(':checked')) ? 'yes' : 'no'; var ST_depression_v4 = ($('.sug-st-depression-v4', category).is(':checked')) ? 'yes' : 'no'; var ST_depression_v5 = ($('.sug-st-depression-v5', category).is(':checked')) ? 'yes' : 'no'; var ST_depression_v6 = ($('.sug-st-depression-v6', category).is(':checked')) ? 'yes' : 'no'; var ST_depression_I = ($('.sug-st-depression-I', category).is(':checked')) ? 'yes' : 'no'; var ST_depression_II = ($('.sug-st-depression-II', category).is(':checked')) ? 'yes' : 'no'; var ST_depression_III = ($('.sug-st-depression-III', category).is(':checked')) ? 'yes' : 'no'; var ST_depression_aVR = ($('.sug-st-depression-aVR', category).is(':checked')) ? 'yes' : 'no'; var ST_depression_aVL = ($('.sug-st-depression-aVL', category).is(':checked')) ? 'yes' : 'no'; var ST_depression_aVF = ($('.sug-st-depression-aVF', category).is(':checked')) ? 'yes' : 'no'; var t_wave_abnormal = ($('.sug-t-wave-abnormal-1', category).is(':checked') || $('.sug-t-wave-abnormal-2', category).is(':checked')) ? 'yes' : 'no'; var t_wave_abnormal_v1 = ($('.sug-t-wave-abnormal-v1', category).is(':checked')) ? 'yes' : 'no'; var t_wave_abnormal_v2 = ($('.sug-t-wave-abnormal-v2', category).is(':checked')) ? 'yes' : 'no'; var t_wave_abnormal_v3 = ($('.sug-t-wave-abnormal-v3', category).is(':checked')) ? 'yes' : 'no'; var t_wave_abnormal_v4 = ($('.sug-t-wave-abnormal-v4', category).is(':checked')) ? 'yes' : 'no'; var t_wave_abnormal_v5 = ($('.sug-t-wave-abnormal-v5', category).is(':checked')) ? 'yes' : 'no'; var t_wave_abnormal_v6 =
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($('.sug-t-wave-abnormal-v6', category).is(':checked')) ? 'yes' : 'no'; var t_wave_abnormal_I = ($('.sug-t-wave-abnormal-I', category).is(':checked')) ? 'yes' : 'no'; var t_wave_abnormal_II = ($('.sug-t-wave-abnormal-II', category).is(':checked')) ? 'yes' : 'no'; var t_wave_abnormal_III = ($('.sug-t-wave-abnormal-III', category).is(':checked')) ? 'yes' : 'no'; var t_wave_abnormal_aVR = ($('.sug-t-wave-abnormal-aVR', category).is(':checked')) ? 'yes' : 'no'; var t_wave_abnormal_aVL = ($('.sug-t-wave-abnormal-aVL', category).is(':checked')) ? 'yes' : 'no'; var t_wave_abnormal_aVF = ($('.sug-t-wave-abnormal-aVF', category).is(':checked')) ? 'yes' : 'no';var qrs_interval = ($('.sug-qrs-interval', category).val() < 0.07 ) ? 'narrow' : ($('.sug-qrs-interval').val() > 0.11 ) ? 'broad' : 'normal'; var qt_interval = ($('.sug-qt-interval', category).val() < 0.36) ? 'narrow' : ($('.sug-qt-interval').val() > 0.44 ) ? 'broad' : 'normal'; var rr_interval = ($('.sug-rr-interval', category).val() < 0.6) ? 'narrow' : ($('.sug-rr-interval').val() > 1.2 ) ? 'broad' : 'normal'; var qtc_interval = $('.QTc-output', category).val(); var qtc_interval_value = ( qtc_interval < 0.35 ) ? 'narrow' : ( qtc_interval > 0.44 ) ? 'broad' : 'normal';var r_progress = ($('.sug-r-progress', category).is(':checked')) ? 'abnormal' : 'normal'; var suspected_chest_lead_misplacement = ($('.sug-chest-misplacement', category).is(':checked')) ? 'yes' : 'no'; var suspected_limb_lead_misplacement = ($('.sug-limb-misplacement', category).is(':checked')) ? 'yes' : 'no';// All question array var suggestion_arrays = [], regular_rhythm_array = [], HR_array = [], P_QRS_association_array = [], sinus_array = [], p_wave_array = [], p_wave_type_array = [], pr_interval_varying_array = [], p_wave_dur_array = [], p_wave_amp_array = [], pr_interval_varying_array = [], pr_interval_array = [], qrs_axis_value_array = [], q_wave_array = [], q_wave_v1_array = [], q_wave_v2_array = [], q_wave_v3_array = [], q_wave_v4_array = [], q_wave_v5_array = [], q_wave_v6_array = [], q_wave_I_array = [], q_wave_II_array = [], q_wave_III_array = [], q_wave_aVR_array = [], q_wave_aVL_array = [], q_wave_aVF_array = [], ST_elevation_array = [], ST_elevation_septal_array = [], ST_elevation_anterior_array = [], ST_elevation_inferior_array = [], ST_elevation_lateral_array = [], ST_depression_array = [], ST_depression_v1_array = [], ST_depression_v2_array = [], ST_depression_v3_array = [], ST_depression_v4_array = [], ST_depression_v5_array = [], ST_depression_v6_array = [], ST_depression_I_array = [], ST_depression_II_array = [], ST_depression_III_array = [], ST_depression_aVR_array = [], ST_depression_aVL_array = [], ST_depression_aVF_array = [], t_wave_abnormal_array = [], t_wave_abnormal_v1_array = [], t_wave_abnormal_v2_array = [], t_wave_abnormal_v3_array = [], t_wave_abnormal_v4_array = [], t_wave_abnormal_v5_array = [], t_wave_abnormal_v6_array = [], t_wave_abnormal_I_array = [], t_wave_abnormal_II_array = [], t_wave_abnormal_III_array = [], t_wave_abnormal_aVR_array = [], t_wave_abnormal_aVL_array = [], t_wave_abnormal_aVF_array = [], qrs_interval_array = [], qt_interval_array = [], rr_interval_array = [], qtc_interval_value_array = [], r_progress_array = [], suspected_chest_lead_misplacement_array = [], suspected_limb_lead_misplacement_array = [];$.getJSON('json/ECG_individual_default_criteria.json', function(data) { // For development - removes cashing for json data $.ajaxSetup({ cache: false }); $.each(data, function(i, ecg) {if(ecg.criteria.regular_rhythm == regular_rhythm) { regular_rhythm_array.push(ecg.name); }; if (ecg.criteria.HR == HR) { HR_array.push(ecg.name); }; if (ecg.criteria.P_QRS_association == P_QRS_association) { P_QRS_association_array.push(ecg.name); }; if (ecg.criteria.sinus == sinus) { sinus_array.push(ecg.name); };if (ecg.criteria.p_wave == p_wave) { p_wave_array.push(ecg.name); }; if (ecg.criteria.p_wave_type == p_wave_type) {
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p_wave_type_array.push(ecg.name); }; if (ecg.criteria.p_wave_dur == p_wave_dur) {
p_wave_dur_array.push(ecg.name); }; if (ecg.criteria.p_wave_amp == p_wave_amp) {
p_wave_amp_array.push(ecg.name); }; if (ecg.criteria.pr_interval_varying ==
pr_interval_varying) { pr_interval_varying_array.push(ecg.name); }; if
(ecg.criteria.pr_interval == pr_interval) { pr_interval_array.push(ecg.name); };if
(ecg.criteria.qrs_axis_value == qrs_axis_value) {
qrs_axis_value_array.push(ecg.name); };if (ecg.criteria.q_wave == q_wave) {
q_wave_array.push(ecg.name); }; if (ecg.criteria.q_wave_v1 == q_wave_v1) {
q_wave_v1_array.push(ecg.name); }; if (ecg.criteria.q_wave_v2 == q_wave_v2) {
q_wave_v2_array.push(ecg.name); }; if (ecg.criteria.q_wave_v3 == q_wave_v3) {
q_wave_v3_array.push(ecg.name); }; if (ecg.criteria.q_wave_v4 == q_wave_v4) {
q_wave_v4_array.push(ecg.name); }; if (ecg.criteria.q_wave_v5 == q_wave_v5) {
q_wave_v5_array.push(ecg.name); }; if (ecg.criteria.q_wave_v6 == q_wave_v6) {
q_wave_v6_array.push(ecg.name); }; if (ecg.criteria.q_wave_I == q_wave_I) {
q_wave_I_array.push(ecg.name); }; if (ecg.criteria.q_wave_II == q_wave_II) {
q_wave_II_array.push(ecg.name); }; if (ecg.criteria.q_wave_III == q_wave_III) {
q_wave_III_array.push(ecg.name); }; if (ecg.criteria.q_wave_aVR == q_wave_aVR) {
q_wave_aVR_array.push(ecg.name); }; if (ecg.criteria.q_wave_aVL == q_wave_aVL) {
q_wave_aVL_array.push(ecg.name); }; if (ecg.criteria.q_wave_aVF == q_wave_aVF) {
q_wave_aVF_array.push(ecg.name); };if (ecg.criteria.ST_elevation == ST_elevation) {
ST_elevation_array.push(ecg.name); }; if (ecg.criteria.ST_elevation_septal ==
ST_elevation_septal) { ST_elevation_septal_array.push(ecg.name); }; if
(ecg.criteria.ST_elevation_inferior == ST_elevation_inferior) {
ST_elevation_inferior_array.push(ecg.name); }; if
(ecg.criteria.ST_elevation_anterior == ST_elevation_anterior) {
ST_elevation_anterior_array.push(ecg.name); }; if
(ecg.criteria.ST_elevation_lateral == ST_elevation_lateral) {
ST_elevation_lateral_array.push(ecg.name); };if (ecg.criteria.ST_depression ==
ST_depression) { ST_depression_array.push(ecg.name); }; if
(ecg.criteria.ST_depression_v1 == ST_depression_v1) {
ST_depression_v1_array.push(ecg.name); }; if (ecg.criteria.ST_depression_v2 ==
ST_depression_v2) { ST_depression_v2_array.push(ecg.name); }; if
(ecg.criteria.ST_depression_v3 == ST_depression_v3) {
ST_depression_v3_array.push(ecg.name); }; if (ecg.criteria.ST_depression_v4 ==
ST_depression_v4) { ST_depression_v4_array.push(ecg.name); }; if
(ecg.criteria.ST_depression_v5 == ST_depression_v5) {
ST_depression_v5_array.push(ecg.name); }; if (ecg.criteria.ST_depression_v6 ==
ST_depression_v6) { ST_depression_v6_array.push(ecg.name); }; if
(ecg.criteria.ST_depression_I == ST_depression_I) {
ST_depression_I_array.push(ecg.name); }; if (ecg.criteria.ST_depression_II ==
ST_depression_II) { ST_depression_II_array.push(ecg.name); }; if
(ecg.criteria.ST_depression_III == ST_depression_III) {
ST_depression_III_array.push(ecg.name); }; if (ecg.criteria.ST_depression_aVR ==
ST_depression_aVR) { ST_depression_aVR_array.push(ecg.name); }; if
(ecg.criteria.ST_depression_aVL == ST_depression_aVL) {
ST_depression_aVL_array.push(ecg.name); }; if (ecg.criteria.ST_depression_aVF ==
ST_depression_aVF) { ST_depression_aVF_array.push(ecg.name); };if
(ecg.criteria.t_wave_abnormal == t_wave_abnormal) {
t_wave_abnormal_array.push(ecg.name); }; if (ecg.criteria.t_wave_abnormal_v1 ==
t_wave_abnormal_v1) { t_wave_abnormal_v1_array.push(ecg.name); }; if
(ecg.criteria.t_wave_abnormal_v2 == t_wave_abnormal_v2) {
t_wave_abnormal_v2_array.push(ecg.name); }; if (ecg.criteria.t_wave_abnormal_v3 ==
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t_wave_abnormal_v3) { t_wave_abnormal_v3_array.push(ecg.name); }; if
(ecg.criteria.t_wave_abnormal_v4 == t_wave_abnormal_v4) {
t_wave_abnormal_v4_array.push(ecg.name); }; if (ecg.criteria.t_wave_abnormal_v5 ==
t_wave_abnormal_v5) { t_wave_abnormal_v5_array.push(ecg.name); }; if
(ecg.criteria.t_wave_abnormal_v6 == t_wave_abnormal_v6) {
t_wave_abnormal_v6_array.push(ecg.name); }; if (ecg.criteria.t_wave_abnormal_I ==
t_wave_abnormal_I) { t_wave_abnormal_I_array.push(ecg.name); }; if
(ecg.criteria.t_wave_abnormal_II == t_wave_abnormal_II) {
t_wave_abnormal_II_array.push(ecg.name); }; if (ecg.criteria.t_wave_abnormal_III ==
t_wave_abnormal_III) { t_wave_abnormal_III_array.push(ecg.name); }; if
(ecg.criteria.t_wave_abnormal_aVR == t_wave_abnormal_aVR) {
t_wave_abnormal_aVR_array.push(ecg.name); }; if (ecg.criteria.t_wave_abnormal_aVL
== t_wave_abnormal_aVL) { t_wave_abnormal_aVL_array.push(ecg.name); }; if
(ecg.criteria.t_wave_abnormal_aVF == t_wave_abnormal_aVF) {
t_wave_abnormal_aVF_array.push(ecg.name); };if (ecg.criteria.qrs_interval ==
qrs_interval) { qrs_interval_array.push(ecg.name); }; if (ecg.criteria.qt_interval
== qt_interval) { qt_interval_array.push(ecg.name); }; if (ecg.criteria.rr_interval
== rr_interval) { rr_interval_array.push(ecg.name); }; if
(ecg.criteria.qtc_interval_value == qtc_interval_value) {
qtc_interval_value_array.push(ecg.name); }; if (ecg.criteria.t_wave_abnormal_aVF ==
t_wave_abnormal_aVF) { t_wave_abnormal_aVF_array.push(ecg.name); };if
(ecg.criteria.r_progress == r_progress) { r_progress_array.push(ecg.name); }; if
(ecg.criteria.suspected_chest_lead_misplacement ==
suspected_chest_lead_misplacement) {
suspected_chest_lead_misplacement_array.push(ecg.name); }; if
(ecg.criteria.suspected_limb_lead_misplacement == suspected_limb_lead_misplacement)
{ suspected_limb_lead_misplacement_array.push(ecg.name); };}); // CLOSES GETJSON
FUNCTION//2D suggestion array containing all other arrays of data depending on each
questions responce suggestion_arrays.push( regular_rhythm_array, HR_array,
P_QRS_association_array, sinus_array, p_wave_array, p_wave_type_array,
pr_interval_varying_array, p_wave_dur_array, p_wave_amp_array,
pr_interval_varying_array, pr_interval_array, qrs_axis_value_array, q_wave_array,
q_wave_v1_array, q_wave_v2_array, q_wave_v3_array, q_wave_v4_array,
q_wave_v5_array, q_wave_v6_array, q_wave_I_array, q_wave_II_array,
q_wave_III_array, q_wave_aVR_array, q_wave_aVL_array, q_wave_aVF_array,
ST_elevation_array, ST_elevation_septal_array, ST_elevation_inferior_array,
ST_elevation_anterior_array, ST_elevation_lateral_array, ST_depression_array,
ST_depression_v1_array, ST_depression_v2_array, ST_depression_v3_array,
ST_depression_v4_array, ST_depression_v5_array, ST_depression_v6_array,
ST_depression_I_array, ST_depression_II_array, ST_depression_III_array,
ST_depression_aVR_array, ST_depression_aVL_array, ST_depression_aVF_array,
t_wave_abnormal_array, t_wave_abnormal_v1_array, t_wave_abnormal_v2_array,
t_wave_abnormal_v3_array, t_wave_abnormal_v4_array, t_wave_abnormal_v5_array,
t_wave_abnormal_v6_array, t_wave_abnormal_I_array, t_wave_abnormal_II_array,
t_wave_abnormal_III_array, t_wave_abnormal_aVR_array, t_wave_abnormal_aVL_array,
t_wave_abnormal_aVF_array, qrs_interval_array, qt_interval_array,
rr_interval_array, qtc_interval_value_array, r_progress_array,
suspected_chest_lead_misplacement_array, suspected_limb_lead_misplacement_array
);//Making an object of suggested results based on frequency of diagnoses in array
(name : frequency) suggestion_object = {}; $.each(suggestion_arrays, function(index,
array) { $.each(array, function(diagnoses, value) {
if(!suggestion_object[array[diagnoses]]) { suggestion_object[array[diagnoses]] = 0;
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}        ++suggestion_object[array[diagnoses]];        });        });        //
console.log(JSON.stringify(suggestion_object, null, " "));//CONVERTS COUNT INTO
PERCENTAGE OF CRITERIA MET and creates a new object //Making an object of suggested
results based on percentage of criteria met (name : percentage)
sorted_suggestion_percentage_object = []; $.each(data, function(i, ecg) {
$.each(suggestion_object, function(name, count) { if (name == ecg.name) { var length
= $.map(ecg.criteria, function(n, i) { return i; }).length; var
percentage_criteria_match = Math.round( ((count / length) * 100) * 10) / 10; var
sensitivity = ecg.sensitivity; var specificity = ecg.specificity; if
(ecg.conclusive_criteria == "Yes") { var conclusive = "Conclusive criteria"; }else
{ var conclusive = "<span class='warning'> Warning - not conclusive criteria
</span>";         };         sorted_suggestion_percentage_object.push([ecg.name,
percentage_criteria_match, sensitivity, specificity, conclusive]); } }); });//
console.log(JSON.stringify(sorted_suggestion_percentage_object, null, " ")); //sort
array sorted_suggestion_percentage_object.sort(function(a, b) {return b[1] -
a[1]})//Shorten array to a criteria match with more than 50% for(var i =
sorted_suggestion_percentage_object.length;        i--;        )        {
if(sorted_suggestion_percentage_object[i][1]        <        50)        {
sorted_suggestion_percentage_object.splice(i,        1);        }        }        //
console.log(sorted_suggestion_percentage_object);//DOM manipulation to create array
items in a list //Appending fragment to ol becasause its much faster var frag1 =
document.createDocumentFragment();      $.each(sorted_suggestion_percentage_object,
function(i,        suggestion_item)        {        var        row        =
document.createElement('tr');if($(window).width() > 768) { // responsiveness ftw var
sug_name                =                document.createElement('td');
sug_name.appendChild(document.createTextNode(suggestion_item[0]));
sug_name.className = "sug_name" ; row.appendChild( sug_name ); var sug_percentage =
document.createElement('td');
sug_percentage.appendChild(document.createTextNode(suggestion_item[1] + "%"));
row.appendChild( sug_percentage ); var sug_notes = document.createElement('td');
sug_notes.innerHTML = suggestion_item[4]; row.appendChild( sug_notes ); var
sug_view_criteria                =                document.createElement('td');
sug_view_criteria.appendChild(document.createTextNode("View criteria - "));
sug_view_criteria.className = "suggestion_button" ; var sug_view_criteria_icon =
document.createElement('i'); sug_view_criteria_icon.className = "fa fa-chevron-
down" ; sug_view_criteria.appendChild(sug_view_criteria_icon); row.appendChild(
sug_view_criteria ); } else { // small screen responsiveness ftw $(".suggestions
table tr", category).children('th').eq(0).css("width", "inherit"); $(".suggestions
table tr", category).children('th').eq(1).hide(); $(".suggestions table tr",
category).children('th').eq(2).hide();      $(".suggestions      table      tr",
category).children('th').eq(3).hide();      $(".suggestions      table      tr",
category).children('th').eq(4).hide();var sug_name = document.createElement('td');
sug_name.appendChild(document.createTextNode(suggestion_item[0]));
sug_name.className = "sug_name" ; row.appendChild( sug_name ); var sug_view_criteria
=                                        document.createElement('td');
sug_view_criteria.appendChild(document.createTextNode("View      metrics      "));
sug_view_criteria.className = "suggestion_button" ; var sug_view_criteria_icon =
document.createElement('i'); sug_view_criteria_icon.className = "fa fa-chevron-
down" ; sug_view_criteria.appendChild(sug_view_criteria_icon); row.appendChild(
sug_view_criteria ); }frag1.appendChild(row); }); var suggestions_context =
$(".suggestions        table        tbody",        category);
$(frag1.cloneNode(true)).hide().appendTo(suggestions_context).slideToggle(800,
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"easeInOutExpo");//Collecting all suggestions for input, adding a comma, and saving
them to input "suggestion_gathering" var suggestion_elements = $(".suggestions table
tbody tr td:nth-child(1)", category).map(function () { return $(this).text();
}).get().join(", "); $(".suggestion_gathering", category).val( suggestion_elements
); }); });//Adding criteria to suggested diagnoses on click $("body").on("click",
".suggestion_button", function(){ if (!$(this).attr('data-toggled') ||
$(this).attr('data-toggled') == 'off'){ //creating toggle on function
$(this).attr('data-toggled','on');$(this).html("Hide criteria <i class='fa fa-
chevron-up' aria-hidden='true'>"); var that = $(this); var suggestion_search_term =
$(this).siblings('.sug_name').text();
$.getJSON('json/ECG_individual_default_criteria.json', function(data) {
$.each(data, function(i, ecg) { if (ecg.name == suggestion_search_term) {
if($(window).width() > 768) { // responsiveness ftw var lists = $("<tr
class='suggestion_lists'></tr>"); var list = $("<td class='criteria-list'></td>");
var list_div_one = $("<div class='hidden-criteria'><h3>Matching
criteria</h3></div>"); $.each(ecg.criteria, function(j, criteria) {
list_div_one.append('<li class="criteria-data">'+ j +':' + criteria+ '</li>'); });
var other_list = $("<td class='other-list'></td>"); var list_div_two = $("<div
class='hidden-criteria'><h3>Other criteria</h3></div>");
$.each(ecg.incompatible_criteria, function(j, criteria) { list_div_two.append('<li
class="criteria-data">' + criteria+ '</li>'); });list.append(list_div_one);
other_list.append(list_div_two); var alignment = "<td></td>";
lists.append(alignment, list, alignment, other_list);var parent_row =
$(that).closest("tr"); parent_row.css("background-color", "#f5f5f5");
lists.insertAfter( parent_row ); } else { var lists_1 = $("<tr
class='suggestion_lists'></tr>"); var lists_2 = $("<tr
class='suggestion_lists'></tr>"); var lists_3 = $("<tr class='suggestion_lists'
style='border-bottom: 1px solid #687E9A;'></tr>");var length = $.map(ecg.criteria,
function(n, i) { return i; }).length; var percentage_criteria_match = Math.round(
((count / length) * 100) * 10) / 10; var sug_percentage =
document.createElement('td'); sug_percentage.innerHTML = "<span>Criteria
match:</span> " + percentage_criteria_match + "%"; lists_1.append( sug_percentage );
if (ecg.conclusive_criteria == "Yes") { var conclusive = "Conclusive criteria"; }else
{ var conclusive = "<span class='warning'> Warning - not conclusive criteria
</span>"; }; var sug_conclusive = document.createElement('td');
sug_conclusive.innerHTML = "<span>Conclusive:</span> " + conclusive; lists_2.append(
sug_conclusive );var list = $("<td class='criteria-list'></td>"); var list_div_one
= $("<div class='hidden-criteria'><h3>Matching criteria</h3></div>");
$.each(ecg.criteria, function(j, criteria) { list_div_one.append('<li
class="criteria-data">'+ j +':' + criteria+ '</li>'); }); list.append( list_div_one
); lists_3.append( list );var other_list = $("<td class='other-list'></td>"); var
list_div_two = $("<div class='hidden-criteria'><h3>Other criteria</h3></div>");
$.each(ecg.incompatible_criteria, function(j, criteria) { list_div_two.append('<li
class="criteria-data">' + criteria+ '</li>'); }); other_list.append( list_div_two );
lists_3.append( other_list );var parent_row = $(that).closest("tr");
parent_row.css({ 'background-color' : '#f5f5f5', 'border-top' : '1px solid
#687E9A'}); parent_row.after( lists_1, lists_2, lists_3 );}var criteria_row =
$(that).closest("tr").siblings(".suggestion_lists"); $(".hidden-criteria",
criteria_row).slideDown("slow"); } }); }); } else if ($(this).attr('data-toggled')
== 'on'){ //creating toggle off function $(this).attr('data-toggled','off');
$(this).html("View criteria <i class='fa fa-chevron-down' aria-hidden='true'></i>");
var parent_row = $(this).closest("tr"); parent_row.css({ 'background-color' :
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'#fff', 'border' : 'none'}); if($(window).width() > 768) { // responsiveness ftw var criteria_row = $(this).closest("tr").siblings(".suggestion_lists"); } else { var criteria_row = $(this).closest("tr").nextAll().slice(0,3); } var clear_list = $(".hidden-criteria", criteria_row).slideUp("slow"); setTimeout(function() { $(criteria_row).remove(); }, 400); } });});
```

ECG_criteria.json

[{ "id":1, "name":"Left Bundle Branch Block (LBBB)", "group":"Conduction Abnormalities", "sensitivity":100, "specificity":48, "prevalence":"NA", "severity":"5", "criteria":{ "qrs_axis":"LAD", "qrs_interval":"broad", "r_progress":"abnormal" }, "incompatible_criteria":{ "1":"Monomorphic R wave in I,V5,and V6", "2":"Prolonged R wave peak time > 60ms in left precordial leads (V5-6)", "3":"Notched R wave in lateral leads" }, "conclusive_criteria":"No", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007. 6) http://europace.oxfordjournals.org/content/15/12/1816.short" }, { "id":2, "name":"Right Bundle Branch Block (RBBB)", "group":"Conduction Abnormalities", "sensitivity":3, "specificity":4, "prevalence":"NA", "severity":"5", "criteria":{ "ST_depression":"yes", "ST_depression_v1":"yes", "ST_depression_v2":"yes", "ST_depression_v3":"yes", "t_wave_abnormal":"yes", "t_wave_abnormal_v1":"yes", "t_wave_abnormal_v2":"yes", "t_wave_abnormal_v3":"yes", "qrs_interval":"broad" }, "incompatible_criteria":{ "1":"Wide,slurred S wave in the lateral leads (I,aVL,V5-6)", "2":"RSR’ pattern in V1-3 (‘M-shaped’ QRS complex)" }, "conclusive_criteria":"No - see incompatible_criteria", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":3, "name":"First Degree AV Block", "group":"Conduction Abnormalities", "sensitivity":5, "specificity":6, "prevalence":"NA", "severity":"5", "criteria":{ "pr_interval":"broad" }, "incompatible_criteria":{ "1":"If PR interval > 300 ms,P waves could be buried in the preceding T wave" }, "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":4, "name":"Second Degree AV Block Type I (Wenckebach / Mobitz I)", "group":"Conduction Abnormalities", "sensitivity":7, "specificity":8, "prevalence":"NA", "severity":"5", "criteria":{

"P_QRS_association":"no", "pr_interval_varying":"yes", "qrs_interval":"narrow" }, "incompatible_criteria":{ "1":"Progressive prolongation of the PR interval culminating in a non-conducted P wave" }, "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":5, "name":"Second Degree AV Block Type II (Mobitz II)", "group":"Conduction Abnormalities", "sensitivity":3, "specificity":10, "prevalence":"NA", "severity":"5", "criteria":{ "P_QRS_association":"no", "qrs_interval":"broad" }, "incompatible_criteria":{ "1":"The P waves ‘march through’ at a constant rate", "2":"ECG indicates dropped QRS complexes" }, "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":6, "name":"Third Degree AV Block (complete heart block)", "group":"Conduction Abnormalities", "sensitivity":11, "specificity":12, "prevalence":"NA", "severity":"5", "criteria":{ "pr_interval_varying":"yes", "P_QRS_association":"no" }, "incompatible_criteria":{ "1":"AV dissociation", "2":"The atrial rate is approximately 100 bpm", "3":"The ventricular rate is approximately 40 bpm" }, "conclusive_criteria":"no", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":7, "name":"Myocardial Ischaemia", "group":"MI", "sensitivity":13, "specificity":14, "prevalence":"NA", "severity":"5", "criteria":{ "ST_depression":"yes", "ST_depression_v1":"yes", "ST_depression_v2":"yes", "ST_depression_v3":"yes", "ST_depression_v4":"yes", "ST_depression_v5":"yes", "ST_depression_v6":"yes", "ST_depression_I":"yes", "ST_depression_II":"yes", "ST_depression_III":"yes", "ST_depression_aVR":"yes", "ST_depression_aVL":"yes", "ST_depression_aVF":"yes", "t_wave_abnormal":"yes", "t_wave_abnormal_v1":"yes", "t_wave_abnormal_v2":"yes", "t_wave_abnormal_v3":"yes", "t_wave_abnormal_v4":"yes", "t_wave_abnormal_v5":"yes", "t_wave_abnormal_v6":"yes", "t_wave_abnormal_I":"yes", "t_wave_abnormal_II":"yes", "t_wave_abnormal_III":"yes", "t_wave_abnormal_aVR":"yes", "t_wave_abnormal_aVL":"yes", "t_wave_abnormal_aVF":"yes" }, "incompatible_criteria":{ "1":"U-wave inversion." }, "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-

8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":8, "name":"STEMI", "group":"MI", "sensitivity":15, "specificity":16, "prevalence":"NA", "severity":"5", "criteria":{ "ST_elevation":"yes" }, "incompatible_criteria":{ "1":"ACC/AHA guidelines for a STEMI:1. ST-segment elevation ≥ 1mm (0.1 mV) in 2 or more adjacent limb leads (from aVL to III,including -aVR)", "2":"ACC/AHA guidelines for a STEMI:2. ST-segment elevation ≥ 1 mm (0.1 mV) in precordial leads V4 through V6", "3":"ACC/AHA guidelines for a STEMI:3. ST-segment elevation ≥ 2 mm (0.2 mV) in precordial leads V1 through V3", "4":"ACC/AHA guidelines for a STEMI:4. New left bundle-branch block"}, "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":9, "name":"STEMI Anterior", "group":"Ischemic Heart Disease", "sensitivity":17, "specificity":18, "prevalence":"NA", "severity":"5", "criteria":{ "ST_elevation":"yes", "ST_elevation_anterior":"yes" }, "incompatible_criteria":{ "1":"ST elevation is concave downward and frequently overwhelms the T wave", "2":"This is called tombstoning due to the similarity to the shape of a tombstone", "3":"The ventricular rate is approximately 40 bpm", "4":"ACC/AHA guidelines for a STEMI:1. ST-segment elevation ≥ 1mm (0.1 mV) in 2 or more adjacent limb leads (from aVL to III,including -aVR)", "5":"ACC/AHA guidelines for a STEMI:2. ST-segment elevation ≥ 1 mm (0.1 mV) in precordial leads V4 through V6", "6":"ACC/AHA guidelines for a STEMI:3. ST-segment elevation ≥ 2 mm (0.2 mV) in precordial leads V1 through V3", "7":"ACC/AHA guidelines for a STEMI:4. New left bundle-branch block"}, "conclusive_criteria":"Yes", "notes":"Contradictions in which leads indicate an anterior STEMI", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":10, "name":"STEMI (Lateral)", "group":"Ischemic Heart Disease", "sensitivity":19, "specificity":20, "prevalence":"NA", "severity":"5", "criteria":{ "ST_elevation":"yes", "ST_elevation_lateral":"yes" }, "incompatible_criteria":{ "1":"ACC/AHA guidelines for a STEMI:1. ST-segment elevation ≥ 1mm (0.1 mV) in 2 or more adjacent limb leads (from aVL to III,including -aVR)", "2":"ACC/AHA guidelines for a STEMI:2. ST-segment elevation ≥ 1 mm (0.1 mV) in precordial leads V4 through V6", "3":"ACC/AHA guidelines for a STEMI:3. ST-segment elevation ≥ 2 mm (0.2 mV) in precordial leads V1 through V3", "4":"ACC/AHA guidelines for a STEMI:4. New left bundle-branch block"}, "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill

Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":11, "name":"STEMI (Inferior)", "group":"Ischemic Heart Disease", "sensitivity":21, "specificity":22, "prevalence":"NA", "severity":"5", "criteria":{ "ST_elevation":"yes", "ST_elevation_inferior":"yes" }, "incompatible_criteria":{ "1":"ACC/AHA guidelines for a STEMI:1. ST-segment elevation ≥ 1mm (0.1 mV) in 2 or more adjacent limb leads (from aVL to III,including -aVR)", "2":"ACC/AHA guidelines for a STEMI:2. ST-segment elevation ≥ 1 mm (0.1 mV) in precordial leads V4 through V6", "3":"ACC/AHA guidelines for a STEMI:3. ST-segment elevation ≥ 2 mm (0.2 mV) in precordial leads V1 through V3", "4":"ACC/AHA guidelines for a STEMI:4. New left bundle-branch block"}, "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":12, "name":"STEMI (Septal)", "group":"Ischemic Heart Disease", "sensitivity":23, "specificity":24, "prevalence":"NA", "severity":"5", "criteria":{ "ST_elevation":"yes", "ST_elevation_septal":"yes" }, "incompatible_criteria":{ "1":"ACC/AHA guidelines for a STEMI:1. ST-segment elevation ≥ 1mm (0.1 mV) in 2 or more adjacent limb leads (from aVL to III,including -aVR)", "2":"ACC/AHA guidelines for a STEMI:2. ST-segment elevation ≥ 1 mm (0.1 mV) in precordial leads V4 through V6", "3":"ACC/AHA guidelines for a STEMI:3. ST-segment elevation ≥ 2 mm (0.2 mV) in precordial leads V1 through V3", "4":"ACC/AHA guidelines for a STEMI:4. New left bundle-branch block"}, "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":12, "name":"NSTEMI", "group":"Ischemic Heart Disease", "sensitivity":23, "specificity":24, "prevalence":"NA", "severity":"5", "criteria":{ "ST_depression":"yes", "t_wave_abnormal":"yes" }, "incompatible_criteria":{ "1":"Persistent or transient ST-segment depression", "2":"T-wave inversion", "3":"Flat T-waves or pseudo-normalization of T-waves", "4":"Otherwise normal ECG, but patient has acute chest pain", "5":"ECG changes in combination with positive troponin is highly suggestive of NSTEMI"}, "conclusive_criteria":"No", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007., 6) http://www.slideshare.net/ThinkDifferentEvents/ecg-interpretation-nstemi-58520107" }, { "id":13, "name":"Sinus Tachycardia", "group":"Atrial Arrhythmias", "sensitivity":25, "specificity":26, "prevalence":"NA", "severity":"5", "criteria":{ "HR":"rapid" }, "incompatible_criteria":{ "1":"With very fast heart rates the P waves may be hidden in the preceding T wave,producing a ‘camel hump’ appearance" }, "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":14, "name":"Sinus Bradycardia", "group":"Atrial Arrhythmias", "sensitivity":27, "specificity":28, "prevalence":"NA", "severity":"5", "criteria":{ "HR":"slow" }, "incompatible_criteria":"", "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":15, "name":"Sinus Arrhythmia", "group":"Atrial Arrhythmias", "sensitivity":29, "specificity":30, "prevalence":"NA", "severity":"5", "criteria":{ }, "incompatible_criteria":{ "1":"The P-P interval gradually lengthens and shortens in a cyclical fashion,usually corresponding to the phases of the respiratory cycle" }, "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":16, "name":"Atrial Fibrillation", "group":"Atrial Arrhythmias", "sensitivity":80, "specificity":92, "prevalence":"NA", "severity":"5", "criteria":{ "regular_rhythm":"irregular", "HR":"rapid", "p_wave":"no", "p_wave_type":"fibrillation", "t_wave_abnormal":"yes" }, "incompatible_criteria":{ "1":"Absence of an isoelectric baseline", "2":"Variable ventricular rate" }, "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007. 6) http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1952490/" }, { "id":17, "name":"Atrial Flutter", "group":"Atrial Arrhythmias", "sensitivity":33, "specificity":34, "prevalence":"NA", "severity":"5", "criteria":{ "p_wave":"no", "p_wave_type":"flutter" }, "incompatible_criteria":{ "1":"Loss of the isoelectric baseline", "2":"Narrow complex tachycardia", "3":"Regular atrial activity at ~300 bpm" }, "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in

Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott's Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":18, "name":"Ventricular Tachycardia", "group":"Ventricular Arrhythmias", "sensitivity":35, "specificity":36, "prevalence":"NA", "severity":"5", "criteria":{ "HR":"rapid", "sinus":"no", "p_wave":"no", "p_wave_type":"none", "t_wave_abnormal":"yes", "qrs_interval":"broad" }, "incompatible_criteria":{ "1":"three or more successive rapid ventricualr depolarisations,with a broad QRS complex and a rapid rate", "2":"Narrow complex tachycardia", "3":"Regular atrial activity at ~300 bpm" }, "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1. Goldbergers Clinical Electrocardiography:AL Goldberger,Z Goldberger,A Schvilkin 2. ECGs by example:Dean Jenkins,Stephen Gerred 3. Manual of Electrocardiography:Gilbert H Mudge" }, { "id":19, "name":"Junctional Rhythm", "group":"Ventricular Arrhythmias", "sensitivity":37, "specificity":38, "prevalence":"NA", "severity":"5", "criteria":{ "HR":"slow", "P_QRS_association":"no", "p_wave":"no", "p_wave_type":"none", "qrs_interval":"broad" }, "incompatible_criteria":{ "1":"P wave may be inverted,buried within the QRS complex,slightly before the QRS complex or slightly after the QRS complex" }, "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott's Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":20, "name":"Supraventricular Tachycardia", "group":"Ventricular Arrhythmias", "sensitivity":39, "specificity":40, "prevalence":"NA", "severity":"5", "criteria":{ "HR":"rapid", "sinus":"no", "p_wave":"no", "p_wave_type":"none", "ST_depression":"yes", "ST_depression_v1":"yes", "ST_depression_v2":"yes", "ST_depression_v3":"yes", "ST_depression_v4":"yes", "ST_depression_v5":"yes", "ST_depression_v6":"yes", "ST_depression_I":"yes", "ST_depression_II":"yes", "ST_depression_III":"yes", "ST_depression_aVR":"yes", "ST_depression_aVL":"yes", "ST_depression_aVF":"yes", "t_wave_abnormal":"yes", "t_wave_abnormal_v1":"yes", "t_wave_abnormal_v2":"yes", "t_wave_abnormal_v3":"yes", "t_wave_abnormal_v4":"yes", "t_wave_abnormal_v5":"yes", "t_wave_abnormal_v6":"yes", "t_wave_abnormal_I":"yes", "t_wave_abnormal_II":"yes", "t_wave_abnormal_III":"yes", "t_wave_abnormal_aVR":"yes", "t_wave_abnormal_aVL":"yes", "t_wave_abnormal_aVF":"yes", "qrs_interval":"narrow" }, "incompatible_criteria":"", "conclusive_criteria":"Yes", "notes":"", "criteria_references":"Goldbergers Clinical Electrocardiography:AL Goldberger,Z Goldberger,A Schvilkin 2. ECGs by example:Dean Jenkins,Stephen Gerred 3. Manual of Electrocardiography:Gilbert H Mudge" }, { "id":21, "name":"Left Atrial Enlargement (LAE)", "group":"Chamber Enlargements", "sensitivity":41, "specificity":42, "prevalence":"NA", "severity":"5", "criteria":{ "p_wave_type":"mitrale", "p_wave_dur":"large" }, "incompatible_criteria":{ "1":"In V1:Biphasic P wave with terminal negative portion > 40 ms duration", "2":"In V1:Biphasic P wave with terminal negative portion > 1mm deep" }, "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and

Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":22, "name":"Right Atrial Enlargement (RAE)", "group":"Chamber Enlargements", "sensitivity":43, "specificity":44, "prevalence":"NA", "severity":"5", "criteria":{ "p_wave_type":"pulmonale", "p_wave_amp":"large" }, "incompatible_criteria":{ "1":"The upward deflection of the P wave in lead V1 greater than 1.5 millimeters in amplitude" }, "conclusive_criteria":"No", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":23, "name":"Bi-atrial Enlargement", "group":"Chamber Enlargements", "sensitivity":45, "specificity":46, "prevalence":"NA", "severity":"5", "criteria":{ "p_wave_type":"mitrale", "p_wave_dur":"large", "p_wave_amp":"large" }, "incompatible_criteria":{ "1":"Initial positive deflection ≥ 1.5mm tall", "2":"Terminal negative deflection ≥ 1mm deep", "3":"Terminal negative deflection ≥ 40 ms duration", "4":"P wave positive deflection ≥ 1.5 mm in leads V1 or V2", "5":"Notched P waves with duration >120 ms in limb leads,V5 or V6" }, "conclusive_criteria":"No", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":24, "name":"Left Ventricular Hypertrophy (LVH)", "group":"Chamber Enlargements", "sensitivity":47, "specificity":48, "prevalence":"NA", "severity":"5", "criteria":{ "p_wave_type":"mitrale", "p_wave_dur":"large", "qrs_axis":"LAD", "ST_elevation":"yes", "ST_elevation_v1":"yes", "ST_elevation_v2":"yes", "ST_elevation_v3":"yes", "ST_depression":"yes", "ST_depression_v5":"yes", "ST_depression_v6":"yes", "ST_depression_I":"yes", "ST_depression_aVL":"yes", "t_wave_abnormal":"yes", "t_wave_abnormal_v5":"yes", "t_wave_abnormal_v6":"yes", "t_wave_abnormal_I":"yes", "t_wave_abnormal_aVL":"yes" }, "incompatible_criteria":{ "1":"Modified Cornell Criteria:Examine the R wave in aVL. If the R wave is > 12 mm in amplitude,then LVH is present", "2":"Sokolow-Lyon Criteria:Add the S wave in V1 plus the R wave in V5 or V6. If the sum is > 35 mm,then LVH is present.", "3":"Increased R wave peak time > 50 ms in leads V5 or V6" }, "conclusive_criteria":"No", "notes":"Romhilt-Estes LVH Point Score System,is used for LVH voltage criteria. Other non-voltage criteria was attained elsewhere", "criteria_references":"1. Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogram. Circulation. 2009;119:e235-240. 2. Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e " }, { "id":25, "name":"Right Ventricular Hypertrophy (RVH)", "group":"Chamber Enlargements", "sensitivity":49, "specificity":50, "prevalence":"NA", "severity":"5", "criteria":{ "p_wave_type":"pulmonale", "p_wave_amp":"large", "qrs_axis":"RAD", "ST_depression":"yes", "ST_depression_v1":"yes", "ST_depression_v2":"yes", "ST_depression_v3":"yes", "ST_depression_II":"yes", "ST_depression_III":"yes", "ST_depression_aVF":"yes", "t_wave_abnormal":"yes", "t_wave_abnormal_v1":"yes", "t_wave_abnormal_v2":"yes", "t_wave_abnormal_v3":"yes", "t_wave_abnormal_II":"yes", "t_wave_abnormal_III":"yes", "t_wave_abnormal_aVF":"yes" }, "incompatible_criteria":{ "1":"Dominant S wave in V5 or V6 (> 7mm deep or R/S ratio < 1)", "2":"Dominant R wave in V1 (> 7mm tall or R/S ratio > 1)" }, "conclusive_criteria":"No", "notes":"", "criteria_references":"1. Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogram. Circulation. 2009;119:e235-240. 2. Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e " }, { "id":26, "name":"Poor R Wave Progression", "group":"Chamber Enlargements", "sensitivity":51, "specificity":52, "prevalence":"NA", "severity":"10", "criteria":{ "r_progress":"abnormal" }, "incompatible_criteria":"", "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1. Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogram. Circulation. 2009;119:e235-240. 2. Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e " }, { "id":27, "name":"Right Arm - Left Arm Reversal", "group":"Miscellaneous", "sensitivity":53, "specificity":54, "prevalence":"NA", "severity":"5", "criteria":{ "t_wave_abnormal":"yes", "t_wave_abnormal_I":"yes", "suspected_limb_lead_misplacement":"yes" }, "incompatible_criteria":{ "1":"Predominantly negative P wave,QRS complex,and T wave in lead I.", "2":"Predominantly upward P wave,QRS complex,and T wave in aVR" }, "conclusive_criteria":"No", "notes":"", "criteria_references":"1. Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogram. Circulation. 2009;119:e235-240. 2. Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e" }, { "id":28, "name":"Dextrocardia", "group":"Miscellaneous", "sensitivity":55, "specificity":56, "prevalence":"NA", "severity":"5", "criteria":{ "qrs_axis":"RAD", "t_wave_abnormal":"yes", "t_wave_abnormal_I":"yes", "r_progress":"abnormal" }, "incompatible_criteria":{ "1":"Low voltage in leads V3-V6" }, "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1. Surawicz B,Knilans TK. Chou’s Electrocardiography in Clinical Practice. 6th Edition. Saunders Elsevier 2008. 2. Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":29, "name":"Chest leads placement error (V1-V5 reversal)", "group":"Miscellaneous", "sensitivity":57, "specificity":58, "prevalence":"NA", "severity":"5", "criteria":{ "r_progress":"abnormal", "suspected_chest_lead_misplacement":"yes" }, "incompatible_criteria":"", "conclusive_criteria":"Yes", "notes":"", "criteria_references":"Allison V. Rosen,Sahil Koppikar,Catherine Shaw,Adrian Baranchuk. Common ECG Lead Placement Errors. Part II:Precordial Misplacements." }, { "id":30, "name":"Pericarditis", "group":"Miscellaneous", "sensitivity":59, "specificity":60, "prevalence":"NA", "severity":"5", "criteria":{ "HR":"rapid", "ST_elevation":"yes", "ST_elevation_v2":"yes", "ST_elevation_v3":"yes", "ST_elevation_v4":"yes", "ST_elevation_v5":"yes", "ST_elevation_v6":"yes", "ST_elevation_I":"yes", "ST_elevation_II":"yes", "ST_elevation_III":"yes", "ST_elevation_aVL":"yes", "ST_elevation_aVF":"yes", "ST_depression":"yes", "ST_depression_aVR":"yes" }, "incompatible_criteria":"", "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":31, "name":"Pulmonary Embolism", "group":"Miscellaneous", "sensitivity":61, "specificity":62, "prevalence":"NA", "severity":"5", "criteria":{ "HR":"rapid", "p_wave_amp":"large", "qrs_axis":"RAD", "ST_depression":"yes", "ST_depression_v1":"yes", "ST_depression_v2":"yes", "ST_depression_v3":"yes", "t_wave_abnormal":"yes", "t_wave_abnormal_v1":"yes", "t_wave_abnormal_v2":"yes", "t_wave_abnormal_v3":"yes", "t_wave_abnormal_v4":"yes", "t_wave_abnormal_II":"yes", "t_wave_abnormal_III":"yes", "t_wave_abnormal_aVF":"yes" }, "incompatible_criteria":{ "1":"Dominant R wave in V1 ", "2":"AF,flutter,atrial tachycardia. Seen in 8% of patients.", "3":"Non-specific ST segment and T wave changes,including ST elevation and depression. Reported in up to 50% of patients with PE.", "4":"The ECG is neither sensitive nor specific enough to diagnose or exclude PE. Around 18% of patients with PE will have a completely normal ECG" }, "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":32, "name":"Wolff-Parkinson-White Syndrome (WPW)", "group":"Miscellaneous", "sensitivity":63, "specificity":64, "prevalence":"NA", "severity":"5", "criteria":{ "pr_interval":"narrow", "q_wave":"yes", "q_wave_v1":"yes", "q_wave_v2":"yes", "q_wave_v3":"yes", "q_wave_v4":"yes", "q_wave_v5":"yes", "q_wave_v6":"yes", "q_wave_I":"yes", "q_wave_II":"yes", "q_wave_III":"yes", "q_wave_aVR":"yes", "q_wave_aVL":"yes", "q_wave_aVF":"yes", "ST_elevation":"yes", "ST_elevation_v1":"yes", "ST_elevation_v2":"yes", "ST_elevation_v3":"yes", "ST_elevation_v4":"yes", "ST_elevation_v5":"yes", "ST_elevation_v6":"yes", "ST_elevation_I":"yes", "ST_elevation_II":"yes", "ST_elevation_III":"yes", "ST_elevation_aVR":"yes", "ST_elevation_aVL":"yes", "ST_elevation_aVF":"yes", "ST_depression":"yes", "ST_depression_v1":"yes", "ST_depression_v2":"yes", "ST_depression_v3":"yes", "ST_depression_v4":"yes", "ST_depression_v5":"yes", "ST_depression_v6":"yes", "ST_depression_I":"yes", "ST_depression_II":"yes", "ST_depression_III":"yes", "ST_depression_aVR":"yes", "ST_depression_aVL":"yes", "ST_depression_aVF":"yes", "t_wave_abnormal":"yes", "t_wave_abnormal_v1":"yes", "t_wave_abnormal_v2":"yes", "t_wave_abnormal_v3":"yes", "t_wave_abnormal_v4":"yes", "t_wave_abnormal_v5":"yes", "t_wave_abnormal_v6":"yes", "t_wave_abnormal_I":"yes", "t_wave_abnormal_II":"yes", "t_wave_abnormal_III":"yes", "t_wave_abnormal_aVR":"yes", "t_wave_abnormal_aVL":"yes", "t_wave_abnormal_aVF":"yes", "qrs_interval":"broad" }, "incompatible_criteria":{ "1":"Delta wave – slurring slow rise of initial portion of the QRS", "2":"Therefore,'pseudo-Q waves' can be seen" }, "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott

Williams & Wilkins 2007." }, { "id":33, "name":"Hyperkalaemia", "group":"Miscellaneous", "sensitivity":65, "specificity":66, "prevalence":"NA", "severity":"5", "criteria":{ "p_wave_dur":"broad", "pr_interval":"broad", "t_wave_abnormal":"yes", "t_wave_abnormal_v1":"yes", "t_wave_abnormal_v2":"yes", "t_wave_abnormal_v3":"yes", "t_wave_abnormal_v4":"yes", "t_wave_abnormal_v5":"yes", "t_wave_abnormal_v6":"yes", "qrs_interval":"broad" }, "incompatible_criteria":{ "1":"P-wave may dissapear altogether and replaced with a 'sine wave' pattern", "2":"Any kind of conduction block may be present", "3":"Sinus bradycardia or slow AF" }, "conclusive_criteria":"Yes", "notes":"If Serum potassium level > 9.0 mEq/L:Asystole,Ventricular fibrillation,PEA with bizarre,wide complex rhythm", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott's Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":34, "name":"Hypokalaemia", "group":"Miscellaneous", "sensitivity":67, "specificity":68, "prevalence":"NA", "severity":"5", "criteria":{ "p_wave_dur":"broad", "p_wave_amp":"large", "pr_interval":"broad", "ST_depression":"yes", "ST_depression_v1":"yes", "ST_depression_v2":"yes", "ST_depression_v3":"yes", "ST_depression_v4":"yes", "ST_depression_v5":"yes", "ST_depression_v6":"yes", "ST_depression_I":"yes", "ST_depression_II":"yes", "ST_depression_III":"yes", "ST_depression_aVR":"yes", "ST_depression_aVL":"yes", "ST_depression_aVF":"yes", "t_wave_abnormal":"yes", "t_wave_abnormal_v1":"yes", "t_wave_abnormal_v2":"yes", "t_wave_abnormal_v3":"yes", "t_wave_abnormal_v4":"yes", "t_wave_abnormal_v5":"yes", "t_wave_abnormal_v6":"yes", "t_wave_abnormal_I":"yes", "t_wave_abnormal_II":"yes", "t_wave_abnormal_III":"yes", "t_wave_abnormal_aVR":"yes", "t_wave_abnormal_aVL":"yes", "t_wave_abnormal_aVF":"yes", "qtc_interval":"broad" }, "incompatible_criteria":{ "1":"Prominent U waves (best seen in the precordial leads)" }, "conclusive_criteria":"Yes", "notes":"With worsening hypokalaemia:1) Frequent supraventricular and ventricular ectopics,2) Supraventricular tachyarrhythmias:AF,atrial flutter,atrial tachycardia,3) Potential to develop life-threatening ventricular arrhythmias,e.g. VT,VF and Torsades de Pointes", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott's Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":35, "name":"Hypercalcaemia", "group":"Miscellaneous", "sensitivity":68, "specificity":70, "prevalence":"NA", "severity":"5", "criteria":{ "qtc_interval":"narrow" }, "incompatible_criteria":{ "1":"Osborn waves (J waves) may be seen", "2":"A shortened ST segment" }, "conclusive_criteria":"Yes", "notes":"Ventricular irritability and VF arrest has been reported with extreme hypercalcaemia", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-

8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":36, "name":"Hypocalcaemia", "group":"Miscellaneous", "sensitivity":71, "specificity":72, "prevalence":"NA", "severity":"5", "criteria":{ "qtc_interval":"broad" }, "incompatible_criteria":{ "1":"Osborn waves (J waves) may be seen", "2":"A prolonged ST segment", "3":"Polymorphic ventricular tachycardia (Torsades de pointes) may occur", "4":"The T wave is typically left unchanged" }, "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":37, "name":"Hypomagnesaemia", "group":"Miscellaneous", "sensitivity":73, "specificity":74, "prevalence":"NA", "severity":"5", "criteria":{ "qtc_interval":"broad" }, "incompatible_criteria":{ "1":"Atrial and ventricular ectopy,atrial tachyarrhythmias and torsades de pointes are seen in the context of hypomagnesaemia,although whether this is a specific effect of low serum magnesium or due to concurrent hypokalaemia is uncertain." }, "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":38, "name":"Wellens Syndrome", "group":"Miscellaneous", "sensitivity":75, "specificity":76, "prevalence":"NA", "severity":"5", "criteria":{ "q_wave":"yes", "q_wave_v1":"yes", "q_wave_v2":"yes", "q_wave_v3":"yes", "q_wave_v4":"yes", "q_wave_v5":"yes", "q_wave_v6":"yes", "t_wave_abnormal":"yes", "t_wave_abnormal_v1":"yes", "t_wave_abnormal_v2":"yes", "t_wave_abnormal_v3":"yes", "t_wave_abnormal_v4":"yes", "t_wave_abnormal_v5":"yes", "t_wave_abnormal_v6":"yes", "r_progress":"yes" }, "incompatible_criteria":{ "1":"T-waves may be biphasic" }, "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott’s Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":39, "name":"Digoxin Effect", "group":"Miscellaneous", "sensitivity":77, "specificity":78, "prevalence":"NA", "severity":"5", "criteria":{ "ST_depression":"yes", "ST_depression_v1":"yes", "ST_depression_v2":"yes", "ST_depression_v3":"yes", "ST_depression_v4":"yes", "ST_depression_v5":"yes", "ST_depression_v6":"yes", "ST_depression_I":"yes", "ST_depression_II":"yes", "ST_depression_III":"yes", "ST_depression_aVR":"yes", "ST_depression_aVL":"yes", "ST_depression_aVF":"yes", "t_wave_abnormal":"yes", "t_wave_abnormal_v1":"yes", "t_wave_abnormal_v2":"yes", "t_wave_abnormal_v3":"yes", "t_wave_abnormal_v4":"yes", "t_wave_abnormal_v5":"yes", "t_wave_abnormal_v6":"yes",

"t_wave_abnormal_I":"yes", "t_wave_abnormal_II":"yes", "t_wave_abnormal_III":"yes", "t_wave_abnormal_aVR":"yes", "t_wave_abnormal_aVL":"yes", "t_wave_abnormal_aVF":"yes", "qtc_interval":"narrow" }, "incompatible_criteria":{ "1":"Mild PR interval prolongation of up to 240 ms", "2":"Prominent U waves", "3":"J point depression (usually in leads with tall R waves)" }, "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott's Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":40, "name":"Benign Early Repolarisation (J-point elevation,high take-off)", "group":"Miscellaneous", "sensitivity":79, "specificity":80, "prevalence":"NA", "severity":"5", "criteria":{ "ST_elevation":"yes", "ST_elevation_v2":"yes", "ST_elevation_v3":"yes", "ST_elevation_v4":"yes", "ST_elevation_v5":"yes", "t_wave_abnormal":"yes", "t_wave_abnormal_v2":"yes", "t_wave_abnormal_v3":"yes", "t_wave_abnormal_v4":"yes", "t_wave_abnormal_v5":"yes", "t_wave_abnormal_v6":"yes", "t_wave_abnormal_I":"yes", "t_wave_abnormal_II":"yes", "t_wave_abnormal_III":"yes", "t_wave_abnormal_aVR":"yes", "t_wave_abnormal_aVF":"yes" }, "incompatible_criteria":{ "1":"Notching or slurring at the J-point", "2":"No reciprocal ST depression to suggest STEMI (except in aVR)" }, "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1) Surawicz B et al. ACC/AHA recommendations for the standardization and interpretation of the electrocardiogra. Circulation. 2009;119:e235-240. 2) Chou's Electrocardiography in Clinical Practice:Adult and Pediatric,6e. 3) Da Costa D,Brady WJ,Edhouse J. Bradycardias and atrioventricular conduction block. BMJ. 2002 Mar 2;324(7336):535-8. Review. PMID:11872557. 4) Hampton,JR. The ECG in Practice (5th edition),Churchill Livingstone 2008. 5) Wagner,GS. Marriott's Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007." }, { "id":41, "name":"Normal Sinus Rhythm", "group":"Normal", "sensitivity":100, "specificity":100, "prevalence":"NA", "severity":"5", "criteria":{ "regular_rhythm":"regular", "HR":"normal", "P_QRS_association":"yes", "sinus":"yes", "p_wave":"yes", "p_wave_type":"normal", "p_wave_dur":"normal", "p_wave_amp":"normal", "pr_interval_varying":"no", "pr_interval":"normal", "qrs_axis":"normal", "q_wave":"no", "q_wave_v1":"no", "q_wave_v2":"no", "q_wave_v3":"no", "q_wave_v4":"no", "q_wave_v5":"no", "q_wave_v6":"no", "q_wave_I":"no", "q_wave_II":"no", "q_wave_III":"no", "q_wave_aVR":"no", "q_wave_aVL":"no", "q_wave_aVF":"no", "ST_elevation":"no", "ST_elevation_v1":"no", "ST_elevation_v2":"no", "ST_elevation_v3":"no", "ST_elevation_v4":"no", "ST_elevation_v5":"no", "ST_elevation_v6":"no", "ST_elevation_I":"no", "ST_elevation_II":"no", "ST_elevation_III":"no", "ST_elevation_aVR":"no", "ST_elevation_aVL":"no", "ST_elevation_aVF":"no", "ST_depression":"no", "ST_depression_v1":"no", "ST_depression_v2":"no", "ST_depression_v3":"no", "ST_depression_v4":"no", "ST_depression_v5":"no", "ST_depression_v6":"no", "ST_depression_I":"no", "ST_depression_II":"no", "ST_depression_III":"no", "ST_depression_aVR":"no", "ST_depression_aVL":"no", "ST_depression_aVF":"no", "t_wave_abnormal":"no", "t_wave_abnormal_v1":"no", "t_wave_abnormal_v2":"no", "t_wave_abnormal_v3":"no", "t_wave_abnormal_v4":"no", "t_wave_abnormal_v5":"no", "t_wave_abnormal_v6":"no", "t_wave_abnormal_I":"no", "t_wave_abnormal_II":"no", "t_wave_abnormal_III":"no", "t_wave_abnormal_aVR":"no", "t_wave_abnormal_aVL":"no", "t_wave_abnormal_aVF":"no", "qrs_interval":"normal", "qt_interval":"normal", "rr_interval":"normal", "qtc_interval":"normal", "r_progress":"normal", "suspected_chest_lead_misplacement":"no", "suspected_limb_lead_misplacement":"no" }, "incompatible_criteria":{ "1":"No other criteria" }, "conclusive_criteria":"Yes", "notes":"", "criteria_references":"1. Surawicz B,Knilans TK. Chou's Electrocardiography in Clinical Practice. 6th Edition. Saunders Elsevier 2008. 2. Wagner,GS. Marriott's Practical Electrocardiography (11th edition),Lippincott Williams & Wilkins 2007" }]

Appendix C: Data for the IPI+DDA system

(Experiemental group)

id, **user_id**, **category_id**, **trial_id**, **age**, **gender**, **occupation**, **experience**, **diagnosed_ecgs**, **consent**, **user_browser**, **user_os**, **time_start**, **S1_Q1_rhythm**, **S1_Q2_heart_rate**, **S1_Q3_qrs_association**, **S1_Q4_sinus_radio**, **S1_time_end**, **Segment 1 time**, **S2_Q1_Pwave**, **S2_Q2_Pwave_type**, **S2_Q3_Pwave_duration**, **S2_Q4_Pwave_amplitude**, **S2_Q5_PR_interval**, **S2_Q6_PR_interval_value**, **S2_time_end**, **Segment 2 time**, **S3_Q1_axis_value**, **S3_Q2_Q_waves**, **S3_Q2_Q_wave_leads**, **S3_Q3_st_segment**, **S3_Q3_st_segment_leads**, **S3_Q4_st_segment_dep**, **S3_Q4_st_segment_dep_leads**, **S3_Q5_t_wave**, **S3_Q5_t_wave_leads**, **S3_time_end**, **Segment 3 time**, **S4_Q1_QRS_duration**, **S4_Q2_QT**, **S4_Q3_R**, **S4_Q4_QTc**, **S4_Q5_q_waves**, **S4_Q5_Q_waves_leads**, **S4_Q6_st_el_wave**, **S4_Q6_ST_elevation_leads**, **S4_Q7_ST_depression**, **S4_Q7_ST_depression_leads**, **S4_Q8_T_wave**, **S4_Q8_T_waves_leads**, **S4_time_end**, **Segment 4 time**, **S5_Q1_R_wave**, **S5_Q2_chest_lead**, **S5_Q3_limb_lead**, **Correct suggestion**, **Correct first Suggestion**, **S5_suggestions**, **Number of suggestions per ECG**, **S5_diagnosis**, **S5_time_end**, **Segment 5 time**, **Total ECG time**
conf_level, Correct / Incorrect

72, **18**, **1**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 88, Yes, Yes, 250.816, 250.82, Yes, normal, 0.08, 2.01, No, NC, 375.657, 124.841, 60, No, , Yes, Array, No, , Yes, Array, 572.333, 196.676, 0.08, 0.36, 0.68, 0.44, Yes, Array, Yes, Array, No, , Yes, Array, 987.277, 414.944, No, No, Yes, TRUE, TRUE, STEMI (Lateral), STEMI Anterior, STEMI, Normal Sinus Rhythm, Right Arm - Left Arm Reversal, Hyperkalaemia, STEMI (Inferior), STEMI (Septal), Benign Early Repolarisation (J-point elevation,high take-off), NSTEMI, 11, STEMI (Lateral),STEMI,STEMI Anterior,, 1527.437, 540.160, 1527.437
4

TRUE

85, **18**, **2**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 71, Yes, Yes, 1783.268, 255.83, Yes, normal, 0.08, 2.1, No, 0.2, 2036.109, 252.841, 60, No, , No, , Yes, Array, Yes, Array, 2261.428, 225.319, 0.04, NC, 0.8, 0.4, No, , Yes, Array, Yes, Array, Yes, Array, 2473.325, 211.897, No, No, No, FALSE, FALSE, STEMI, NSTEMI, Normal Sinus Rhythm, Right Ventricular Hypertrophy (RVH), STEMI Anterior, STEMI (Lateral), STEMI (Inferior), STEMI (Septal), 8, STEMI,, 2554.588, 81.263, 1027.151
4

FALSE

102, **18**, **3**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Not regular, 100, Yes, No, 2786.579, 231.99, Yes, pulmonale, 0.08, 5, No, 0.21, 2941.559, 154.980, 120, No, , No, , Yes, Array, No, , 3140.212, 198.653, 0.04, 0.32, 0.52, 0.44, Yes, Array, Yes, Array, Yes, Array, No, , 3334.815, 194.603, No, Yes, No, TRUE, TRUE, Right Atrial Enlargement (RAE), STEMI Anterior, STEMI, Normal Sinus Rhythm, STEMI (Septal), NSTEMI, STEMI (Lateral), STEMI (Inferior), Chest leads placement error (V1-V5 reversal), 9, STEMI,STEMI Anterior,, 3387.184, 52.369, 832.596

NC

FALSE

115, **18**, **5**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, 3839.798, Regular, 160, Yes, Yes, 3930.833, 543.65, No, other, NC, NC, No, NC, 3990.873, 60.040, 60, No, , No, , No, , No, , 4022.194, 31.3209999999999, 0.04, 0.2, 0.32, 0.35, No, , Yes, Array, No, , No, , 4122.53, 100.336, Yes, No, Yes, FALSE, FALSE, STEMI, Normal Sinus Rhythm, STEMI Anterior, STEMI (Lateral), STEMI (Inferior), STEMI (Septal), Atrial Flutter, 7, STEMI,, 4171.967, 49.437, 784.783
4

FALSE

73, **19**, **1**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 88, Yes, Yes, 264.072, 264.07, Yes, normal, 0.08, 0.2, No, 0.2, 471.278, 207.206, 60, Yes, Array, Yes, Array, Yes, Array, Yes, Array, 739.77, 268.492, 0.08, 0.36, 0.68, 0.44, Yes, Array, Yes, Array, No, , Yes, Array, 1088.605, 348.835, No, No, Yes, TRUE, FALSE, NSTEMI, Right Arm - Left Arm Reversal, STEMI, STEMI (Lateral), Normal Sinus Rhythm, STEMI (Inferior), STEMI (Septal), STEMI Anterior, Benign Early Repolarisation (J-point elevation,high take-off), Hyperkalaemia, Dextrocardia, 12, STEMI (Lateral),STEMI,NSTEMI,Right Arm - Left Arm Reversal,, 1639.833, 551.228, 1639.833

6

TRUE

110, **19**, **3**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 88, No, No, 2987.677, 1347.84, Yes, pulmonale, NC, 5, No, 0.2, 3110.191, 122.514, 60, Yes, Array, No, , No, , Yes, Array, 3358.901, 248.71, 0.08, 0.32, 0.6, 0.41, Yes, Array, No, , No, , No, , 3746.376, 387.475, No, Yes, No, TRUE, TRUE, Right Atrial Enlargement (RAE), Normal Sinus Rhythm, Third Degree AV Block (complete heart block), NSTEMI, Chest leads placement error (V1-V5 reversal), Second Degree AV Block Type II (Mobitz II), 6, Right Atrial Enlargement (RAE),, 3847.732, 101.356, 2207.899

6

TRUE

125, **19**, **4**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 160, No, No, 4000.663, 152.93, No, fibrillation, NC, NC, No, NC, 4040.493, 39.830, 60, No, , Yes, Array, No, , Yes, Array, 4326.353, 285.86, 0.16, 0.28, 0.28, 0.53, No, , Yes, Array, No, , Yes, Array, 4398.182, 71.8289999999997, Yes, No, No, TRUE, FALSE, STEMI, STEMI Anterior, STEMI (Lateral), STEMI (Inferior), Poor R Wave Progression, Normal Sinus Rhythm, Atrial Fibrillation, Dextrocardia, STEMI (Septal), Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), Atrial Flutter, Ventricular Tachycardia, Benign Early Repolarisation (J-point elevation,high take-off), Hyperkalaemia, Chest leads placement error (V1-V5 reversal), NSTEMI, 18, STEMI,Poor R Wave Progression,Atrial Fibrillation,, 4449.925, 51.743, 602.193

NC

FALSE

130, **19**, **5**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, 4451.139, Regular, 160, No, No, 4461.144, 11.22, Yes, mitrale, 0.08, 2.01, No, 0.2, 4526.308, 65.164, 60, No, , No, , Yes, Array, Yes, Array, 4551.1, 24.7920000000004, 0.08, 0.2, 0.32, 0.35, No, , Yes, Array, No, , Yes, Array, 4625.6, 74.5, No, No, No, FALSE, FALSE, NSTEMI, STEMI, Normal Sinus Rhythm, Third Degree AV Block (complete heart block), Left Atrial Enlargement (LAE), Second Degree AV Block Type II (Mobitz II), STEMI Anterior, STEMI (Lateral), STEMI (Inferior), STEMI (Septal), 10, STEMI,Third Degree AV Block (complete heart block),, 4663.082, 37.482, 213.157

NC

FALSE

65, **20**, **1**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 100, Yes, Yes, 106.969, 106.97, Yes, pulmonale, 0.16, 2.99, No, 0.08, 244.785, 137.816, 60, Yes, Array, Yes, Array, No, , Yes, Array, 452.586, 207.801, 0.08, 0.52, 0.68, 0.63, No, , Yes, Array, No, , Yes, Array, 724.125, 271.539, No, No, No, TRUE, TRUE, STEMI, STEMI Anterior, STEMI (Lateral), Right Atrial Enlargement (RAE), Benign Early Repolarisation (J-point elevation,high take-off), Atrial Fibrillation, Bi-atrial Enlargement, Right Arm - Left Arm Reversal, Ventricular Tachycardia, Pulmonary Embolism, Normal Sinus Rhythm, Right Ventricular Hypertrophy (RVH), STEMI (Septal), STEMI (Inferior), Hyperkalaemia, Left Atrial Enlargement (LAE), NSTEMI, Dextrocardia, 19, STEMI,STEMI Anterior,STEMI (Lateral),, 1115.897, 391.772, 1115.897

3

TRUE

76, **20**, **2**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 75, Yes, Yes, 1211.38, 95.48, Yes, pulmonale, NC, 2.01, No, 0.12, 1288.35, 76.970, 60, Yes, Array, No, , No, , Yes, Array, 1436.166, 147.816, 0.04, 0.2, 0.84, 0.22, No, , No, , No, , Yes, Array, 1678.417, 242.251, No, No, No, FALSE, FALSE, Right Arm - Left Arm Reversal, Normal Sinus Rhythm, Atrial Fibrillation, Benign Early Repolarisation (J-point elevation,high take-off), Ventricular Tachycardia, Dextrocardia, Right Atrial Enlargement (RAE), NSTEMI, 9, Benign Early Repolarisation (J-point elevation,high take-off),, 1803.268, 124.851, 687.371

3

FALSE

83, **20**, **3**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Not regular, 100, No, No, 1886.073, 82.81, Yes, pulmonale, NC, 0.5, No, NC, 2008.237, 122.164, 0, Yes, Array, No, , No, , Yes, Array, 2236.058, 227.821, 0.12, 0.24, 0.6, 0.31, No, , No, , No, , No, , 2377.047, 140.989, No, No, No, TRUE, FALSE, Normal Sinus Rhythm, Third Degree AV Block (complete heart block), NSTEMI, Second Degree AV Block Type II (Mobitz II), Right Atrial Enlargement (RAE), 5, Third Degree AV Block (complete heart block),, 2410.847, 33.800, 607.579

2

FALSE

92, **20**, **4**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Not regular, 160, No, No, 2540.213, 129.37, No, fibrillation, NC, NC, No, NC, 2615.249, 75.036, 60, Yes, Array, No, , No, , No, , 2763.984, 148.735, 0.16, 0.8, 0.32, 1.41, Yes, Array, No, , No, , Yes, Array, 2881.637, 117.653, No, No, No, TRUE, FALSE, Wellens Syndrome, Hyperkalaemia, Atrial Fibrillation, Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), NSTEMI, Atrial Flutter, Ventricular Tachycardia, 8, Atrial Fibrillation,, 2939.274, 57.637, 528.427

3

FALSE

103, **20**, **5**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, 2942.106, Regular, 160, Yes, No, 3032.707, 93.43, No, none, NC, NC, No, NC, 3037.139, 4.432, 60, Yes, Array, Yes, Array, No, , Yes, Array, 3149.64, 112.501, 0.04, 0.8, 0.22, 1.71, Yes, Array, No, , No, , Yes, Array, 3340.308, 190.668, No, No, No, FALSE, FALSE, STEMI, Right Arm - Left Arm Reversal, Normal Sinus Rhythm, STEMI Anterior, STEMI (Lateral), Dextrocardia, STEMI (Septal), NSTEMI, Ventricular Tachycardia, Atrial Flutter, STEMI (Inferior), 11, STEMI,, 3359.739, 19.431, 420.465

2

FALSE

60, **21**, **1**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 88, Yes, Yes, 74.641, 74.64, Yes, normal, NC, 1.98, No, 0.2, 140.394, 65.753, 60, No, , No, , No, , No, , 199.827, 59.433, 0.08, 0.44, 1.08, 0.42, No, , No, , No, , No, , 322.614, 122.787, Yes, No, No, FALSE, FALSE, Poor R Wave Progression, Normal Sinus Rhythm, Chest leads placement error (V1-V5 reversal), 3, noirmal sinus rhythm, 410.184, 87.570, 410.184

2

FALSE

64, **21**, **2**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 75, Yes, Yes, 452.376, 42.19, Yes, normal, 0.2, 2.02, No, 0.2, 566.752, 114.376, 59, No, , No, , No, , Yes, Array, 625.286, 58.534, 0.12, NC, 0.9, 0.46, No, , No, , No, , Yes, Array, 757.249, 131.963, No, No, No, FALSE, FALSE, Normal Sinus Rhythm, Right Arm - Left Arm Reversal, Dextrocardia, NSTEMI, Hyperkalaemia, Left Atrial Enlargement (LAE), 6, Normal Sinus Rhythm,with left ventricular hypertrophy , 904.239, 146.990, 494.055

0

TRUE

70, **21**, **3**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 115, Yes, Yes, 959.424, 55.18, Yes, pulmonale, NC, 0.5, No, 0.2, 1047.275, 87.851, 90, No, , No, , No, , No, , 1116.125, 68.8499999999999, 0.1, NC, NC, 0.4, No, , No, , No, , No, , 1190.287, 74.162, No, No, No, TRUE, FALSE, Normal Sinus Rhythm, Right Atrial Enlargement (RAE), 2, normal sinus rhythm with suggested right atrial enlargement , 1317.178, 126.891, 412.939

2

TRUE

79, **21**, **4**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 160, No, No, 1440.747, 123.57, Yes, normal, 0.08, 0.2, Yes, 0.1, 1515.048, 74.301, -150, No, , No, , No, , No, Array, 1733.783, 218.735, 0.11, NC, NC, , No, , No, , No, , No, , 1986.936, 253.153, No, No, No, FALSE, FALSE, Third Degree AV Block (complete heart block), Second Degree AV Block Type I (Wenckebach / Mobitz I), Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), 4, Wolff-Parkinson-White Syndrome (WPW),, 2078.537, 91.601, 761.359

0

FALSE

86, **21**, **5**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 2080.889, Regular, 160, No, No, 2176.471, 2176.47, No, none, NC, NC, No, NC, 2203.347, 26.876, 60, No, , No, , No, , No, , 2267.593, 64.2459999999996, 0.08, 0.36, 0.62, 0.46, No, , No, , No, , No, , 2507.504, 239.911, No, No, No, FALSE, FALSE, Normal Sinus Rhythm, Junctional Rhythm, Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), Atrial Flutter, 5, accelerated junctional rhythm , 2548.417, 40.913, 469.880

2

FALSE

109, **22**, **7**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 40, Yes, Yes, 2309.343, NA, Yes, normal, 0.08, 0.6, No, 0.2, 2311.175, 1.832, -180, No, , No, , No, , No, , 2312.388, 1.21299999999974, 0.08, 0.32, 0.8, 0.36, No, , No, , No, , Yes, Array, 2314.155, 1.76700000000028, No, No, No, FALSE, FALSE, Sinus Bradycardia, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), NSTEMI, 4, Sinus Bradycardia,Second Degree AV Block Type II (Mobitz II),, 2390.693, 76.538, 2390.693

NC

FALSE

124, **22**, **8**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 78, No, No, 2962.687, 571.99, Yes, normal, NC, 1.05, No, 0.2, 2965.71, 3.023, -176, Yes, Array, No, , No, , No, , 2967.173, 1.46299999999974, 0.12, NC, 0.64, 0.4, No, Array, No, , No, , No, , 2969.027, 1.85400000000027, No, No, No, FALSE, FALSE, Sinus Tachycardia, Second Degree AV Block Type II (Mobitz II), Normal Sinus Rhythm, Third Degree AV Block (complete heart block), 4, Normal Sinus Rhythm,Junctional Rhythm,, 3081.541, 112.514, 690.848

NC

FALSE

131, **22**, **9**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 1, Regular, 72, Yes, Yes, 3132.81, 51.27, Yes, mitrale, 0.16, 1.87, No, NC, 3205.446, 72.636, 57, No, , No, , No, , No, , 3231.115, 25.6689999999999, 0.08, NC, 0.8, 0.36, No, , No, , No, , No, , 3314.247, 83.1320000000001, No, No, No, FALSE, FALSE, Left Atrial Enlargement (LAE), Sinus Tachycardia, Normal Sinus Rhythm, Bi-atrial Enlargement, Second Degree AV Block Type II (Mobitz II), 5, Left Atrial Enlargement (LAE),Normal Sinus Rhythm,, 3323.527, 9.280, 241.986

NC

FALSE

135, **22**, **10**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 3324.886, Regular, 53, Yes, Yes, 3382.011, 58.48, Yes, mitrale, 0.15, 1.98, No, 0.16, 3421.816, 39.805, -121, No, , No, , No, , No, , 3473.69, 51.8740000000003, 0.08, 0.36, 0.89, 0.38, No, , No, , No, , Yes, Array, 3556.105, 82.415, No, No, No, TRUE, FALSE, Sinus Bradycardia, Left Atrial Enlargement (LAE), Normal Sinus Rhythm, Bi-atrial Enlargement, Hyperkalaemia, Second Degree AV Block Type II (Mobitz II), NSTEMI, 7, Normal Sinus Rhythm,Left Atrial Enlargement (LAE),, 3586.03, 29.925, 262.503

5

TRUE

82, **23**, **6**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Not regular, 160, No, No, 593.447, 593.45, No, flutter, NC, NC, No, NC, 628.679, 35.232, 120, No, , No, , No, , Yes, Array, 878.44, 249.761, 0.08, 0.28, 0.28, 0.53, Yes, Array, No, , No, , Yes, Array, 1275.704, 397.264, Yes, Yes, No, TRUE, FALSE, Poor R Wave Progression, Chest leads placement error (V1-V5 reversal), Atrial Flutter, Sinus Tachycardia, Atrial Fibrillation, Ventricular Tachycardia, Dextrocardia, Wellens Syndrome, Right Arm - Left Arm Reversal, Pulmonary Embolism, Benign Early Repolarisation (J-point elevation,high take-off), NSTEMI, Second Degree AV Block Type II (Mobitz II), Hyperkalaemia, Third Degree AV Block (complete heart block), 16, accelerated junctional rhythm , 1598.099, 322.395, 1598.099

0

FALSE

99, **23**, **7**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 71, No, No, 1787.333, 189.23, Yes, normal, NC, 2, No, 0.28, 2077.734, 290.401, 180, No, , No, , No, , Yes, Array, 2263.008, 185.274, 0.08, NC, 0.84, 0.44, No, , No, , No, , No, , 2425.874, 162.866, Yes, No, No, FALSE, FALSE, Sinus Tachycardia, Poor R Wave Progression, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), Chest leads placement error (V1-V5 reversal), NSTEMI, Dextrocardia, 8, Normal Sinus Rhythm,, 2472.112, 46.238, 874.013

2

FALSE

108, **23**, **8**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 83, Yes, Yes, 2587.407, 115.30, Yes, normal, 0.04, 1, No, NC, 2656.194, 68.787, 180, No, , No, , No, , No, , 2728.114, 71.9200000000001, 0.08, 0.6, 0.68, 0.73, No, , No, , No, , No, , 2812.655, 84.5410000000002, Yes, Yes, No, FALSE, FALSE, Poor R Wave Progression, Chest leads placement error (V1-V5 reversal), Sinus Tachycardia, Normal Sinus Rhythm, 4, Normal Sinus Rhythm,Poor R Wave Progression,, 2891.381, 78.726, 419.269

2

FALSE

114, **23**, **9**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 68, Yes, Yes, 2944.532, 53.15, Yes, normal, NC, 2, No, 0.2, 3012.056, 67.524, 90, No, , No, , No, , Yes, Array, 3082.521, 70.4650000000001, 0.08, 0.6, 0.84, 0.65, No, , No, , No, , No, , 3160.536, 78.0149999999999, Yes, No, No, TRUE, FALSE, Poor R Wave Progression, Sinus Tachycardia, Dextrocardia, Normal Sinus Rhythm, Right Arm - Left Arm Reversal, Atrial Fibrillation, Ventricular Tachycardia, NSTEMI, Chest leads placement error (V1-V5 reversal), 9, Normal Sinus Rhythm,Left Bundle Branch Block (LBBB),, 3354.152, 193.616, 462.771

1

FALSE

128, **23**, **10**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 3357.039, Not regular, 80, Yes, No, 3471.804, 117.65, Yes, mitrale, 0.08, 1, No, 0.16, 3554.143, 82.339, 30, No, , No, , No, , No, , 3628.976, 74.8330000000001, 0.08, 0.4, 0.92, 0.63, No, , No, , No, , No, , 3697.323, 68.3469999999998, Yes, No, No, TRUE, FALSE, Sinus Tachycardia, Normal Sinus Rhythm, Left Atrial Enlargement (LAE), 3, normal sinus rhythm , 3787.498, 90.175, 433.346

2

TRUE

81, **24**, **6**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Not regular, 90, No, No, 592.649, 592.65, No, none, NC, NC, No, NC, 639.6, 46.951, 120, No, , Yes, Array, No, , Yes, Array, 791.968, 152.368, 0.08, 0.28, 0.28, 0.53, No, , No, , No, , Yes, Array, 1278.539, 486.571, Yes, No, No, TRUE, FALSE, Poor R Wave Progression, STEMI, STEMI (Lateral), Ventricular Tachycardia, Atrial Fibrillation, Dextrocardia, Benign Early Repolarisation (J-point elevation,high take-off), Right Arm - Left Arm Reversal, Pulmonary Embolism, Junctional Rhythm, Normal Sinus Rhythm, STEMI (Septal), Atrial Flutter, STEMI (Inferior), STEMI Anterior, Hyperkalaemia, Chest leads placement error (V1-V5 reversal), Third Degree AV Block (complete heart block), Second Degree AV Block Type II (Mobitz II), NSTEMI, 21, accelerated junctional rhythm, 1581.225, 302.686, 1581.225

2

FALSE

96, **24**, **7**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 75, Yes, No, 1672.908, 91.68, Yes, normal, 0.08, NC, No, 0.2, 1985.029, 312.121, 180, No, , No, , No, , No, , 2213.537, 228.508, 0.08, 0.36, 0.8, 0.4, No, , No, , No, , No, , 2269.144, 55.607, No, No, No, FALSE, FALSE, Normal Sinus Rhythm, 1, Normal Sinus Rhythm,, 2300.759, 31.615, 719.534

4

FALSE

107, **24**, **8**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Not regular, 75, Yes, Yes, 2531.681, 230.92, Yes, none, 0.04, 1, No, NC, 2666.08, 134.399, 180, No, , No, , No, , No, , 2711.335, 45.2550000000001, 0.08, 0.6, 0.68, 0.73, No, , No, , No, , No, , 2805.869, 94.5340000000001, No, No, No, FALSE, FALSE, Normal Sinus Rhythm, 1, Left Bundle Branch Block (LBBB),Normal Sinus Rhythm,, 2830.865, 24.996, 530.106

3

FALSE

116, **24**, **9**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 68, Yes, Yes, 2919.419, 88.55, Yes, normal, NC, 2, No, 0.2, 3032.504, 113.085, 90, No, , No, , No, , Yes, Array, 3083.219, 50.7150000000001, 0.08, NC, 0.84, 0.65, No, , No, , No, , No, , 3142.328, 59.1089999999999, No, No, No, FALSE, FALSE, Normal Sinus Rhythm, Right Arm - Left Arm Reversal, NSTEMI, Dextrocardia, 4, Normal Sinus Rhythm,Left Bundle Branch Block (LBBB),, 3349.389, 207.061, 518.524

2

FALSE

127, **24**, **10**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 3358.076, Not regular, 80, Yes, No, 3472.633, 123.24, Yes, mitrale, 0.08, 1, No, 0.2, 3541.92, 69.287, 30, No, , No, , No, , No, , 3610.217, 68.297, 0.08, 0.36, 0.92, 0.38, No, , No, , No, , No, , 3664.171, 53.9539999999997, No, No, No, TRUE, TRUE, Normal Sinus Rhythm, Left Atrial Enlargement (LAE), 2, Normal Sinus Rhythm,Left Atrial Enlargement (LAE),, 3691.177, 27.006, 341.788

2

TRUE

67, **25**, **1**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Not regular, 88, Yes, Yes, 100.337, 100.34, Yes, normal, 0.08, 2, No, NC, 204.618, 104.281, 60, No, , Yes, Array, No, , Yes, Array, 411.349, 206.731, 0.16, 0.36, 0.68, 0.44, No, , Yes, Array, No, , Yes, Array, 738.099, 326.75, No, No, No, TRUE, TRUE, STEMI (Lateral), STEMI, STEMI Anterior, Hyperkalaemia, Normal Sinus Rhythm, Right Bundle Branch Block (RBBB), Atrial Fibrillation, STEMI (Inferior), Second Degree AV Block Type II (Mobitz II), NSTEMI, Ventricular Tachycardia, STEMI (Septal), 12, Myocardial Ischaemia,, 1177.867, 439.768, 1177.867

NC

TRUE

78, **25**, **2**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 71, Yes, Yes, 1267.302, 89.43, Yes, pulmonale, 0.16, NC, Yes, NC, 1354.395, 87.093, 60, No, , No, , No, , Yes, Array, 1473.193, 118.798, 0.04, 0.36, 0.88, 0.38, No, , Yes, Array, No, , No, , 1647.825, 174.632, No, No, No, FALSE, FALSE, Third Degree AV Block (complete heart block), Second Degree AV Block Type I (Wenckebach / Mobitz I), STEMI, STEMI Anterior, STEMI (Lateral), STEMI (Septal), Normal Sinus Rhythm, STEMI (Inferior), Right Atrial Enlargement (RAE), NSTEMI, Left Atrial Enlargement (LAE), 11, Normal Sinus Rhythm,Left Ventricular Hypertrophy (LVH),Right Ventricular Hypertrophy (RVH),, 1894.245, 246.420, 716.378

NC

TRUE

84, **25**, **3**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 107, No, No, 1986.912, 92.67, Yes, normal, 0.08, 2, Yes, NC, 2091.289, 104.377, 90, Yes, Array, No, , No, , No, , 2266.196, 174.907, 0.12, 0.24, 0.56, 0.32, No, , No, , No, , No, , 2378.376, 112.18, No, No, No, FALSE, FALSE, Third Degree AV Block (complete heart block), Second Degree AV Block Type I (Wenckebach / Mobitz I), Second Degree AV Block Type II (Mobitz II), Normal Sinus Rhythm, 4, Third Degree AV Block (complete heart block),, 2424.357, 45.981, 530.112

NC

FALSE

94, **25**, **4**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 160, No, No, 2610.568, 186.21, No, fibrillation, NC, NC, No, NC, 2641.049, 30.481, 58, Yes, Array, No, , No, , No, , 2755.96, 114.911, 0.16, 0.8, 0.24, 1.63, No, , Yes, Array, No, , No, , 2880.587, 124.627, No, No, No, FALSE, FALSE, Second Degree AV Block Type II (Mobitz II), STEMI, STEMI Anterior, STEMI (Lateral), STEMI (Septal), Normal Sinus Rhythm, Junctional Rhythm, Atrial Flutter, STEMI (Inferior), Third Degree AV Block (complete heart block), 10, Atrial Fibrillation,, 2939.032, 58.445, 514.675

2

FALSE

104, **25**, **5**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 2945.102, Regular, 160, Yes, Yes, 2989.063, 50.03, Yes, normal, NC, NC, No, 0.2, 3084.186, 95.123, 60, Yes, Array, Yes, Array, No, , Yes, Array, 3140.162, 55.9759999999997, 0.06, 0.2, 0.32, 0.35, No, , No, , No, , No, , 3233.537, 93.375, No, No, No, FALSE, FALSE, STEMI, Normal Sinus Rhythm, STEMI (Inferior), STEMI Anterior, STEMI (Lateral), NSTEMI, STEMI (Septal), 7, Sinus Tachycardia,, 3403.755, 170.218, 464.723

1

FALSE

90, **26**, **1**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 88, No, Yes, 85.491, 85.49, Yes, normal, NC, 2.02, No, 0.2, 161.392, 75.901, 60, No, , No, , No, , No, , 181.226, 19.834, 0.02, 0.48, 0.6, 0.62, No, , No, , No, , No, , 277.073, 95.847, No, No, No, FALSE, FALSE, Normal Sinus Rhythm, Second Degree AV Block Type I (Wenckebach / Mobitz I), Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), 4, Normal Sinus Rhythm,, 309.963, 32.890, 309.963

NC

FALSE

95, **26**, **2**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 71, Yes, Yes, 344.417, 34.45, Yes, normal, 0.2, 0.61, No, NC, 408.224, 63.807, 60, No, , No, , No, , Yes, Array, 441.582, 33.358, 0.08, 0.48, 0.84, 0.52, No, , No, , No, , No, , 496.33, 54.748, No, No, No, FALSE, FALSE, Normal Sinus Rhythm, Right Arm - Left Arm Reversal, Dextrocardia, NSTEMI, Left Atrial Enlargement (LAE), 5, Normal Sinus Rhythm,Left Ventricular Hypertrophy (LVH),, 527.347, 31.017, 217.384

7

TRUE

97, **26**, **3**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Not regular, 83, No, No, 564.377, 37.03, No, none, NC, NC, No, NC, 578.064, 13.687, 63, No, , No, , No, , No, , 609.784, 31.72, 0, 0, 0, NaN, No, , No, , No, , No, , 650.866, 41.082, No, No, No, FALSE, FALSE, Normal Sinus Rhythm, Second Degree AV Block Type I (Wenckebach / Mobitz I), Junctional Rhythm, Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), Atrial Flutter, 6, Second Degree AV Block Type I (Wenckebach / Mobitz I),, 664.933, 14.067, 137.586

NC

FALSE

100, **26**, **4**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 160, No, No, 735.967, 71.03, No, fibrillation, NC, NC, No, NC, 742.967, 7.000, 0, No, , No, , No, , No, , 771.399, 28.432, 0, 0, 0, NaN, No, , No, , No, , No, , 785.683, 14.284, No, No, No, FALSE, FALSE, Normal Sinus Rhythm, Second Degree AV Block Type I (Wenckebach / Mobitz I), Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), Atrial Flutter, 5, Ventricular Tachycardia,, 800.232, 14.549, 135.299

6

TRUE

105, **26**, **5**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 801.149, Regular, 136, No, Yes, 834.415, 34.18, Yes, normal, 0.04, 0.1, No, 0.04, 867.079, 32.664, 61, No, , No, , No, , No, , 890.95, 23.8710000000001, 0.04, 0.36, 0.28, 0.68, No, , No, , No, , No, , 943.351, 52.401, No, No, No, FALSE, FALSE, Normal Sinus Rhythm, Second Degree AV Block Type I (Wenckebach / Mobitz I), Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), 4, Sinus Tachycardia,, 955.792, 12.441, 155.560

NC

FALSE

62, **27**, **1**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 88, Yes, Yes, 75.74, 75.74, Yes, normal, 0.08, 1.01, No, NC, 154.757, 79.017, 60, Yes, Array, No, , No, , Yes, Array, 258.142, 103.385, 0.08, 0.44, 0.68, 0.53, No, , No, , No, , No, , 378.856, 120.714, No, Yes, No, FALSE, FALSE, Normal Sinus Rhythm, NSTEMI, Chest leads placement error (V1-V5 reversal), 3, Normal Sinus Rhythm,Chest leads placement error (V1-V5 reversal),, 627.1, 248.244, 627.100

NC

FALSE

66, **27**, **2**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 75, Yes, Yes, 670.268, 43.17, Yes, pulmonale, 0.08, 2.01, No, 0.2, 780.34, 110.072, 60, No, , No, , No, , No, , 822.938, 42.598, 0.12, 0.44, 0.8, 0.49, No, , No, , Yes, Array, Yes, Array, 980.107, 157.169, Yes, No, No, FALSE, FALSE, Poor R Wave Progression, NSTEMI, Normal Sinus Rhythm, Hyperkalaemia, Right Bundle Branch Block (RBBB), Dextrocardia, Right Atrial Enlargement (RAE), Chest leads placement error (V1-V5 reversal), 8, Poor R Wave Progression,NSTEMI,Normal Sinus Rhythm,, 1109.012, 128.905, 481.912

6

FALSE

74, **27**, **3**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Regular, 94, Yes, No, 1255.595, 146.58, Yes, pulmonale, NC, 5, No, NC, 1367.355, 111.760, 90, No, , No, , No, , Yes, Array, 1456.985, 89.6299999999999, 0.08, 0.36, 0.6, 0.46, Yes, Array, No, , No, , Yes, Array, 1600.255, 143.27, No, No, No, TRUE, TRUE, Right Atrial Enlargement (RAE), Normal Sinus Rhythm, NSTEMI, 3, Right Atrial Enlargement (RAE),, 1695.908, 95.653, 586.896

NC

TRUE

80, **27**, **4**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Not regular, 160, No, No, 2155.326, 459.42, No, fibrillation, NC, NC, No, NC, 2156.251, 0.925, -29, No, , No, , No, , No, , 2158.078, 1.82699999999977, 0.08, 0.2, 0.28, 0.38, No, , No, , No, , No, , 2159.923, 1.8449999999998, No, No, No, FALSE, FALSE, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), Atrial Flutter, 4, Atrial Flutter,Supraventricular Tachycardia,, 2241.769, 81.846, 545.861

7

FALSE

88, **27**, **5**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, 2246.318, Regular, 160, No, No, 2305.607, 63.84, No, none, NC, NC, No, NC, 2319.654, 14.047, 60, No, , No, , No, , No, , 2481.261, 161.607, 0.04, 0.2, 0.24, 0.41, No, , No, , No, , No, , 2580.88, 99.6190000000001, No, No, No, FALSE, FALSE, Normal Sinus Rhythm, Second Degree AV Block Type I (Wenckebach / Mobitz I), Junctional Rhythm, Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), Atrial Flutter, 6, Junctional Rhythm,Supraventricular Tachycardia,, 2658.885, 78.005, 417.116

7

TRUE

101, **28**, **6**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 7, USER NOT FINISHED YET, Not regular, 160, No, No, 2095.663, 2095.66, No, none, NC, NC, No, NC, 2098.888, 3.225, 60, No, , No, , No, , No, , 2163.526, 64.6379999999999, 0.12, 0.32, 2, 0.23, No, , No, , No, , No, , 2171.293, 7.76700000000028, Yes, Yes, Yes, TRUE, FALSE, Chest leads placement error (V1-V5 reversal), Second Degree AV Block Type II (Mobitz II), Poor R Wave Progression, Sinus Tachycardia, Junctional Rhythm, Left Bundle Branch Block (LBBB), Normal Sinus Rhythm, Atrial Flutter, Third Degree AV Block (complete heart block), 9, Junctional Tachycardia, 2473.899, 302.606, 2473.899

6

FALSE

117, **28**, **7**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 8, USER NOT FINISHED YET, Regular, 50, No, Yes, 2561.437, 87.54, Yes, normal, NC, 0.2, No, 0.24, 2691.535, 130.098, 180, No, , No, , No, , Yes, Array, 2888.81, 197.275, 0.06, NC, 0.8, 0.36, No, , Yes, Array, No, , Yes, Array, 3054.944, 166.134, Yes, Yes, Yes, TRUE, FALSE, Sinus Bradycardia, Chest leads placement error (V1-V5 reversal), Poor R Wave Progression, STEMI, Right Arm - Left Arm Reversal, Second Degree AV Block Type I (Wenckebach / Mobitz I), Normal Sinus Rhythm, STEMI (Lateral), STEMI (Septal), NSTEMI, STEMI Anterior, Second Degree AV Block Type II (Mobitz II), Dextrocardia, Third Degree AV Block (complete heart block), STEMI (Inferior), 15, Sinus Bradycardia,, 3353.687, 298.743, 879.788

3

FALSE

134, **28**, **8**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 9, USER NOT FINISHED YET, Regular, 83, No, No, 3523.592, 169.91, Yes, mitrale, 0.08, 0.01, No, 0.2, 3618.759, 95.167, -180, No, , Yes, Array, No, , No, , 3707.477, 88.7179999999998, 0.08, 0.32, 0.63, 0.4, No, , No, , No, , No, , 3801.18, 93.703, Yes, No, No, FALSE, FALSE, Poor R Wave Progression, Second Degree AV Block Type II (Mobitz II), Sinus Tachycardia, STEMI, Normal Sinus Rhythm, Left Bundle Branch Block (LBBB), STEMI Anterior, STEMI (Inferior), STEMI (Septal), Third Degree AV Block (complete heart block), Chest leads placement error (V1-V5 reversal), STEMI (Lateral), Left Atrial Enlargement (LAE), 13, Normal Sinus Rhythm,, 3923.615, 122.435, 569.928

1

FALSE

138, **28**, **9**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 10, 3927.232, Regular, 72, Yes, Yes, 3976.151, 52.54, Yes, mitrale, NC, 0.2, No, 0.2, 4035.88, 59.729, 89, Yes, Array, No, , No, , No, , 4067.317, 31.4369999999999, 0.08, NC, 0.93, 0.33, No, , No, , No, , No, , 4106.335, 39.018, No, No, No, FALSE, FALSE, Sinus Tachycardia, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), Left Atrial Enlargement (LAE), 4, Normal Sinus Rhythm,, 4132.072, 25.737, 208.457

3

FALSE

139, **28**, **10**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 11, 4136.224, Regular, 69, No, Yes, 4167.221, 35.15, Yes, mitrale, 0.08, 0.11, No, 0.16, 4211.191, 43.970, 0, No, , No, , No, , No, , 4224.056, 12.8649999999998, 0.09, 0.4, 1, , No, , No, , No, , No, , 4231.393, 7.33700000000044, No, No, No, TRUE, FALSE, Second Degree AV Block Type II (Mobitz II), Sinus Tachycardia, Normal Sinus Rhythm, Third Degree AV Block (complete heart block), Left Atrial Enlargement (LAE), 5, Normal Sinus Rhythm,, 4242.169, 10.776, 110.097

5

TRUE

91, **29**, **6**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 12, USER NOT FINISHED YET, Not regular, 160, No, No, 795.309, 795.31, No, flutter, NC, NC, No, NC, 824.638, 29.329, 120, Yes, Array, Yes, Array, No, , Yes, Array, 836.889, 12.251, 0.18, 0.2, 0.32, 0.35, Yes, Array, Yes, Array, No, , Yes, Array, 1157.111, 320.222, Yes, Yes, No, FALSE, FALSE, Chest leads placement error (V1-V5 reversal), Second Degree AV Block

Type II (Mobitz II), STEMI, Poor R Wave Progression, STEMI (Lateral), Atrial Flutter, Sinus Tachycardia, Dextrocardia, Left Bundle Branch Block (LBBB), Right Arm - Left Arm Reversal, Junctional Rhythm, Wellens Syndrome, Third Degree AV Block (complete heart block), NSTEMI, STEMI (Inferior), Ventricular Tachycardia, STEMI (Septal), STEMI Anterior, 18, Right Bundle Branch Block (RBBB),Ventricular Tachycardia,, 1497.822, 340.711, 1497.822

NC

FALSE

113, **29**, **7**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 13, USER NOT FINISHED YET, Regular, 71, Yes, Yes, 1607.749, 109.93, Yes, normal, 0.08, 0.6, No, 0.24, 1816.814, 209.065, 180, No, , No, , Yes, Array, Yes, Array, 1992.286, 175.472, 0.12, 0.24, 0.88, 0.26, Yes, Array, Yes, Array, No, , Yes, Array, 2291.791, 299.505, No, No, No, TRUE, FALSE, STEMI, Sinus Tachycardia, NSTEMI, Right Arm - Left Arm Reversal, Normal Sinus Rhythm, Right Bundle Branch Block (RBBB), STEMI (Inferior), Second Degree AV Block Type II (Mobitz II), STEMI (Lateral), STEMI Anterior, Dextrocardia, STEMI (Septal), 12, Normal Sinus Rhythm,, 2535.796, 244.005, 1037.974

NC

FALSE

122, **29**, **8**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 14, USER NOT FINISHED YET, Regular, 75, No, No, 2634.445, 98.65, No, other, NC, NC, No, NC, 2667.014, 32.569, 179, Yes, Array, No, , Yes, Array, Yes, Array, 2747.748, 80.7339999999999, 0.12, NC, 0.68, 0.29, No, , Yes, Array, No, , No, , 2932.917, 185.169, No, No, No, TRUE, FALSE, Second Degree AV Block Type II (Mobitz II), STEMI, NSTEMI, Sinus Tachycardia, Right Arm - Left Arm Reversal, Junctional Rhythm, Normal Sinus Rhythm, Dextrocardia, STEMI (Inferior), STEMI (Septal), Atrial Flutter, Third Degree AV Block (complete heart block), STEMI Anterior, STEMI (Lateral), 14, Atrial Flutter,, 3004.685, 71.768, 468.889

NC

FALSE

133, **29**, **9**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 15, 1, Regular, 71, Yes, Yes, 3081.99, 77.30, Yes, mitrale, 0.16, 1.88, No, NC, 3146.301, 64.311, 90, No, , No, , No, , No, , 3187.137, 40.8360000000002, 0.08, NC, 0.84, 0.26, Yes, Array, No, , No, , Yes, Array, 3262.972, 75.835, No, No, No, FALSE, FALSE, Sinus Tachycardia, Left Atrial Enlargement (LAE), Normal Sinus Rhythm, Bi-atrial Enlargement, Second Degree AV Block Type II (Mobitz II), NSTEMI, 6, Right Atrial Enlargement (RAE),Junctional Rhythm,, 3315.742, 52.770, 311.057

NC

FALSE

137, **29**, **10**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 16, 3317.69, Regular, 71, Yes, Yes, 3348.989, 33.25, Yes, mitrale, 0.16, 0.11, No, 0.2, 3426.99, 78.001, -150, No, , No, , No, , Yes, Array, 3485.576, 58.5860000000002, 0.12, 0.8, 0.88, 0.85, No, , No, , No, , No, , 3576.576, 91, No, No, No, TRUE, FALSE, Sinus Tachycardia, Left Atrial Enlargement (LAE), Normal Sinus Rhythm, Bi-atrial Enlargement, Second Degree AV Block Type II (Mobitz II), NSTEMI, 6, Normal Sinus Rhythm,Right Atrial Enlargement (RAE),, 3616.827, 40.251, 301.085
5

TRUE

106, **30**, **7**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 17, USER NOT FINISHED YET, Regular, 70, No, Yes, 1344.422, NA, Yes, normal, 0.08, 0.1, No, 0.2, 1409.083, 64.661, 178, Yes, Array, Yes, Array, No, , No, , 1504.072, 94.9889999999998, 0.08, NC, 0.84, 0.35, Yes, Array, Yes, Array, No, , Yes, Array, 1679.531, 175.459, Yes, No, No, FALSE, FALSE, Poor R Wave Progression, Second Degree AV Block Type II (Mobitz II), Sinus Tachycardia, STEMI, Left Bundle Branch Block (LBBB), Normal Sinus Rhythm, Chest leads placement error (V1-V5 reversal), STEMI Anterior, STEMI (Septal), NSTEMI, Third Degree AV Block (complete heart block), Dextrocardia, STEMI (Inferior), STEMI (Lateral), 14, Poor R Wave Progression,Myocardial Ischaemia,, 1922.466, 242.935, 1922.466

2

FALSE

112, **30**, **8**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 18, USER NOT FINISHED YET, Not regular, 90, No, No, 1989.743, 67.28, Yes, normal, 0.04, 0.1, No, NC, 2066.686, 76.943, -180, Yes, Array, Yes, Array, Yes, Array, Yes, Array, 2176.541, 109.855, NC, NC, NC, , Yes, Array, No, , No, , No, , 2254.899, 78.3579999999997, No, No, No, FALSE, FALSE, Sinus Tachycardia, Second Degree AV Block Type II (Mobitz II), NSTEMI, STEMI, Normal Sinus Rhythm, Third Degree AV Block (complete heart block), STEMI Anterior, STEMI (Lateral), STEMI (Inferior), STEMI (Septal), 10, Left Ventricular Hypertrophy (LVH),, 2320.59, 65.691, 398.12

1

FALSE

118, **30**, **9**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 19, 1261.663, Not regular, 68, Yes, Yes, 2401.886, 81.30, Yes, pulmonale, NC, 0.2, No, 0.2, 2484.876, 82.990, 60, No, , No, , No, , No, , 2515.313, 30.4369999999999, 0.08, NC, 0.92, 0.33, No, Array, Yes, Array, No, , Yes, Array, 2591.101, 75.788, No, No, No, FALSE, FALSE, STEMI, Sinus Tachycardia, Normal Sinus Rhythm, STEMI (Inferior), STEMI Anterior, STEMI (Lateral), Second Degree AV Block Type II (Mobitz II), STEMI (Septal), NSTEMI, Right Atrial Enlargement (RAE), 10, Myocardial Ischaemia,, 2673.616, 82.515, 353.03

1

FALSE

121, **30**, **10**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 20, 2675.732, Regular, 80, No, No, 2691.876, 18.26, Yes, normal, 0.12, 2.5, No, 0.16, 2702.54, 10.664, 0, No, , No, , No, , No, , 2722.338, 19.7980000000002, 0.09, 0.4, 0.8, 0.36, No, , Yes, Array, No, , Yes, Array, 2767.806, 45.4679999999998, Yes, No, No, TRUE, FALSE, STEMI Anterior, Sinus Tachycardia, Second Degree AV Block Type II (Mobitz II), STEMI, Normal Sinus Rhythm, Third Degree AV Block (complete heart block), Hyperkalaemia, STEMI (Lateral), STEMI (Inferior), STEMI (Septal), NSTEMI, 11, Poor R Wave Progression,, 2793.388, 25.582, 119.77

1

FALSE

126, **31**, **7**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 21, USER NOT FINISHED YET, Regular, 68, Yes, Yes, 1780.086, NA, Yes, biphasic, 0.08, 2.01, Yes, 0.08, 2046.021, 265.935, -30, Yes, Array, Yes, Array, Yes, Array, No, , 2547.31, 501.289, 0.08, NC, NC, , No, , No, , No, , No, , 2714.381, 167.071, No, Yes, No, FALSE, FALSE, Sinus Tachycardia, STEMI (Lateral), Third Degree AV Block (complete heart block), STEMI, Second Degree AV Block Type I (Wenckebach / Mobitz I), Normal Sinus Rhythm, Chest leads placement error (V1-V5 reversal), Second Degree AV Block Type II (Mobitz II), STEMI (Inferior), STEMI (Septal), NSTEMI, STEMI Anterior, 12, Chest leads placement error (V1-V5 reversal),, 2825.39, 111.009, 2825.390

2

FALSE

129, **31**, **8**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 22, USER NOT FINISHED YET, Regular, NC, Yes, No, 2840.231, 14.84, No, none, NC, NC, No, NC, 2858.366, 18.135, 92, Yes, Array, Yes, Array, No, , Yes, Array, 2896.13, 37.7640000000001, 0.08, NC, NC, , No, , No, , Yes, Array, No, , 2910.971, 14.8409999999999, Yes, No, Yes, TRUE, FALSE, Poor R Wave Progression, STEMI, Sinus Tachycardia, NSTEMI, Left Bundle Branch Block (LBBB), Right Arm - Left Arm Reversal, Normal Sinus Rhythm, Junctional Rhythm, Second Degree AV Block Type II (Mobitz II), STEMI (Lateral), STEMI Anterior, Chest leads placement error (V1-V5 reversal), Atrial Flutter, Dextrocardia, STEMI (Inferior), STEMI (Septal), 16, Sinus Bradycardia,, 2932.71, 21.739, 107.32

7

FALSE

132, **31**, **9**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 23, 1, Regular, 36, Yes, Yes, 2955.283, 22.57, No, none, NC, NC, No, NC, 2962.884, 7.601, -30, Yes, Array, No, , Yes, Array, No, , 2996.543, 33.6590000000001, 0.12, 0.26, NC, 0.46, No, , No, , No, , No, , 3009.943, 13.4000000000001, Yes, Yes, No, TRUE, TRUE, Chest leads placement error (V1-V5 reversal), Poor R Wave Progression, Sinus Bradycardia, Junctional Rhythm, Normal Sinus Rhythm, Left Bundle Branch Block (LBBB), Atrial Flutter, Second Degree AV Block Type II (Mobitz II), NSTEMI, 9, Normal Sinus Rhythm,, 3038.157, 28.214, 105.45 4

FALSE

136, **31**, **10**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 24, 3041.992, Regular, 71, No, Yes, 3075.458, 37.30, Yes, mitrale, 0.12, 0.2, Yes, 0.16, 3153.225, 77.767, -180, No, , No, , No, , No, , 3207.951, 54.7260000000001, 0.08, 0.08, 1, 0.14, Yes, Array, No, , Yes, Array, No, , 3299.519, 91.5679999999998, Yes, Yes, No, TRUE, FALSE, Third Degree AV Block (complete heart block), Second Degree AV Block Type I (Wenckebach / Mobitz I), Second Degree AV Block Type II (Mobitz II), Sinus Tachycardia, Normal Sinus Rhythm, Left Atrial Enlargement (LAE), NSTEMI, 7, Normal Sinus Rhythm,, 3320.354, 20.835, 282.20 5

TRUE

89, **32**, **6**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 25, USER NOT FINISHED YET, Not regular, 160, No, No, 166.693, 166.69, Yes, mitrale, NC, 0.2, Yes, 0.12, 262.05, 95.357, 118, Yes, Array, No, , No, , Yes, Array, 555.882, 293.832, 0.16, NC, 0.28, Adjust the QT interval, Yes, Array, Yes, Array, No, , Yes, Array, 981.935, 426.053, Yes, Yes, No, FALSE, FALSE, Third Degree AV Block (complete heart block), STEMI (Lateral), Second Degree AV Block Type II (Mobitz II), Poor R Wave Progression, Chest leads placement error (V1-V5 reversal), STEMI, Second Degree AV Block Type I (Wenckebach / Mobitz I), Sinus Tachycardia, Dextrocardia, Right Arm - Left Arm Reversal, Left Bundle Branch Block (LBBB), Wellens Syndrome, STEMI Anterior, Left Atrial Enlargement (LAE), STEMI (Inferior), STEMI (Septal), NSTEMI, 17, Right Bundle Branch Block (RBBB),Right Atrial Enlargement (RAE),Ventricular Tachycardia,, 1246.647, 264.712, 1246.647

NC

FALSE

111, **32**, **7**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 26, USER NOT FINISHED YET, Regular, 71, Yes, Yes, 1324.171, 77.52, Yes, normal, 0.08, 0.1, Yes, 0.2, 1403.148, 78.977, -27, Yes, Array, No, , Yes, Array, Yes, Array, 1513.847, 110.699, 0.12, 0.28, 0.76, 0.32, No, , Yes, Array, No, , No, , 2138.621, 624.774, No, No, No, TRUE, FALSE, Sinus Tachycardia, Third Degree AV Block (complete heart block), NSTEMI, STEMI, Right Arm - Left Arm Reversal, Second Degree AV Block Type I (Wenckebach / Mobitz I), Normal Sinus Rhythm, STEMI (Lateral), STEMI (Inferior), STEMI (Septal), Dextrocardia, Second Degree AV Block Type II (Mobitz II), STEMI Anterior, 13, Normal Sinus Rhythm,, 2275.173, 136.552, 1028.526

NC

FALSE

119, **32**, **8**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 27, 1, Not regular, NC, No, No, 2293.23, 18.06, Yes, pulmonale, NC, 0.02, Yes, NC, 2503.516, 210.286, -28, Yes, Array, No, , Yes, Array, Yes, Array, 2662.705, 159.189, NC, NC, NC, , No, , No, , No, , No, , 2678.425, 15.7200000000003, No, No, No, FALSE, FALSE, Third Degree AV Block (complete heart block), Second Degree AV Block Type I (Wenckebach / Mobitz I), Second Degree AV Block Type II (Mobitz II), NSTEMI, Sinus Tachycardia, Normal Sinus Rhythm, Right Atrial Enlargement (RAE), 7, Poor R Wave Progression,, 2693.516, 15.091, 418.343

NC

FALSE

120, **32**, **9**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 28, 1251.586, Not regular, NC, No, No, 2697.9, 4.38, Yes, none, NC, NC, No, NC, 2701.518, 3.618, 0, No, , No, , Yes, , No, , 2705.169, 3.65099999999984, NC, NC, NC, , No, , No, , Yes, , No, , 2708.375, 3.20600000000013, No, No, Yes, FALSE, FALSE, Second Degree AV Block Type II (Mobitz II), Sinus Tachycardia, Normal Sinus Rhythm, Junctional Rhythm, Third Degree AV Block (complete heart block), NSTEMI, 6, Normal Sinus Rhythm,, 2717.077, 8.702, 23.561

NC

FALSE

123, **32**, **10**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 29, 2721.218, Not regular, 80, Yes, No, 2726.853, 9.78, Yes, normal, 0.08, 0.3, Yes, 0.16, 2803.572, 76.719, -23, No, , Yes, , No, , No, , 2809.261, 5.68899999999985, 0.09, 0.4, 1, , Yes, , No, , No, , No, , 2812.677, 3.41600000000017, No, Yes, No, TRUE, FALSE, Third Degree AV Block (complete heart block), STEMI, Sinus Tachycardia, Normal Sinus Rhythm, Second Degree AV Block Type I (Wenckebach / Mobitz I), Second Degree AV Block Type II (Mobitz II), STEMI Anterior, STEMI (Lateral), STEMI (Inferior), STEMI (Septal), 10, Benign Early Repolarisation (J-point elevation,high take-off),, 2828.84, 16.163, 111.763

5

FALSE

68, **33**, **1**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 30, USER NOT FINISHED YET, Regular, 88, Yes, Yes, 72.62, 72.62, Yes, normal, 0.08, 0.2, No, NC, 187.048, 114.428, 60, No, , No, , No, , No, , 294.394, 107.346, NC, NC, 0.68, Adjust the QT interval, No, , Yes, Array, Yes, Array, Yes, Array, 544.455, 250.061, No, No, No, TRUE, TRUE, STEMI, STEMI Anterior, NSTEMI, Normal Sinus Rhythm, Right Bundle Branch Block (RBBB), STEMI (Inferior), STEMI (Lateral), Hyperkalaemia, STEMI (Septal), 9, Right Bundle Branch Block (RBBB),, 704.565, 160.110, 704.565

4

FALSE

75, **33**, **2**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 31, USER NOT FINISHED YET, Regular, 71, Yes, Yes, 785.002, 80.44, Yes, normal, 0.1, 0.2, No, 0.12, 879.097, 94.095, 60, No, , No, , No, , Yes, Array, 986.26, 107.163, 0.12, NC, NC, , No, , No, , No, , Yes, Array, 1094.374, 108.114, Yes, No, No, FALSE, FALSE, Poor R Wave Progression, Normal Sinus Rhythm, Dextrocardia, Right Arm - Left Arm Reversal, Chest leads placement error (V1-V5 reversal), NSTEMI, 6, Poor R Wave Progression,Left Ventricular Hypertrophy (LVH),, 1260.584, 166.210, 556.019

NC

TRUE

87, **33**, **3**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 32, USER NOT FINISHED YET, Regular, 100, Yes, Yes, 1316.616, 56.03, Yes, pulmonale, 0.08, 0.5, No, 0.12, 1612.309, 295.693, 60, Yes, Array, No, , No, , No, , 1716.092, 103.783, 0.12, 0.16, 0.56, 0.21, Yes, Array, No, , No, , Yes, Array, 2024.183, 308.091, No, No, No, TRUE, FALSE, Normal Sinus Rhythm, NSTEMI, Right Atrial Enlargement (RAE), 3, Right Atrial Enlargement (RAE),, 2073.109, 48.926, 812.525

NC

TRUE

93, **33**, **4**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 33, USER NOT FINISHED YET, Not regular, 160, Yes, No, 2200.677, 127.57, No, fibrillation, NC, NC, No, NC, 2222.995, 22.318, 59, Yes, Array, Yes, Array, No, , No, , 2279.858, 56.8630000000003, 0.1, NC, 0.28, 0.3, Yes, Array, No, , No, , No, , 2377.69, 97.8319999999999, Yes, No, No, FALSE, FALSE, STEMI (Lateral), STEMI (Inferior), Poor R Wave Progression, STEMI, Normal Sinus Rhythm, STEMI Anterior, STEMI (Septal), Atrial Flutter, Chest leads placement error (V1-V5 reversal), 9, Ventricular Tachycardia,, 2453.419, 75.729, 380.310

7

TRUE

98, **33**, **5**, UUJ, <30, female, Student, <10, 10s, Consent given, Chrome, Windows 34, 2455.921, Regular, 160, No, No, 2532.544, 79.13, No, none, NC, NC, No, NC, 2539.167, 6.623, 58, No, , No, , No, , No, , 2578.297, 39.1300000000001, 0.08, 0.14, 0.32, 0.25, No, , No, , No, , No, , 2660.317, 82.02, No, No, No, FALSE, FALSE, Normal Sinus Rhythm, Junctional Rhythm, Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), Atrial Flutter, 5, Junctional Rhythm,Left Ventricular Hypertrophy (LVH),, 2702.797, 42.480, 249.378

NC

FALSE

140, **35**, **1**, NWG, 30-40, female, Cardiologist, 10-20, 1000s, Consent given, Firefox, Unknown OS Platform, USER NOT FINISHED YET, Regular, 87, Yes, Yes, 57.935, 57.94, Yes, normal, 0.04, 2.02, No, NC, 220.663, 162.728, 59, No, , No, , No, , No, , 284.791, 64.128, 0.07, 0.32, 0.66, 0.39, No, , No, , No, , No, , 417.319, 132.528, Yes, Yes, No, FALSE, FALSE, Poor R Wave Progression, Chest leads placement error (V1-V5 reversal), Normal Sinus Rhythm, 3, lead displacement in precordial leads, 548.036, 130.717, 548.036

9

FALSE

141, **35**, **2**, NWG, 30-40, female, Cardiologist, 10-20, 1000s, Consent given, Firefox, Unknown OS Platform, USER NOT FINISHED YET, Regular, 69, Yes, Yes, 611.327, 63.29, Yes, pulmonale, NC, NC, No, NC, 796.159, 184.832, 32, Yes, Array, No, , No, , Yes, Array, 864.035, 67.876, NC, NC, 0.89, 0.34, No, , Yes, Array, Yes, Array, Yes, Array, 998.799, 134.764, No, No, No, TRUE, FALSE, STEMI, STEMI (Septal), NSTEMI, Right Arm - Left Arm Reversal, Benign Early Repolarisation (J-point elevation,high take-off), Atrial Fibrillation, Ventricular Tachycardia, Normal Sinus Rhythm, Myocardial Ischaemia, Left Ventricular Hypertrophy (LVH), Digoxin Effect, STEMI Anterior, STEMI (Lateral), STEMI (Inferior), Right Atrial Enlargement (RAE), Dextrocardia, Hyperkalaemia, 18, hypertrophic cardiomyopathy, 1065.304, 66.505, 517.268

8

FALSE

142, **37**, **1**, NWG, 30-40, female, cardiology, 10-20, 1000s, Consent given, Chrome, Windows 7, 1, Regular, 94, Yes, Yes, 36.386, 36.39, Yes, normal, 0.1, 1.8, No, NC, 114.29, 77.904, 61, No, , Yes, Array, Yes, Array, No, , 183.108, 68.818, 0.08, NC, NC, , No, , Yes, Array, No, , No, , 231.439, 48.331, Yes, No, No, TRUE, TRUE, STEMI, STEMI Anterior, STEMI (Lateral), Poor R Wave Progression, Normal Sinus Rhythm, Chest leads placement error (V1-V5 reversal), STEMI (Inferior), STEMI (Septal), NSTEMI, 9, STEMI antero-lateral, 298.451, 67.012, 298.451

9

TRUE

143, **37**, **2**, NWG, 30-40, female, cardiology, 10-20, 1000s, Consent given, Chrome, Windows 8, 307.766, Regular, 72, Yes, Yes, 346.016, 47.57, Yes, pulmonale, NC, NC, No, 0.18, 410.197, 64.181, 30, Yes, Array, No, , Yes, Array, Yes, Array, 512.675, 102.478, NC, NC, NC, , No, , Yes, Array, Yes, Array, Yes, Array, 624.355, 111.68, No, No, No, TRUE, FALSE, NSTEMI, STEMI, STEMI (Septal), Right Arm - Left Arm Reversal, Left Ventricular Hypertrophy (LVH), Benign Early Repolarisation (J-point elevation,high take-off), Myocardial Ischaemia, Digoxin Effect, Atrial Fibrillation, Ventricular Tachycardia, Hypokalaemia, Supraventricular Tachycardia, Normal Sinus Rhythm, Hyperkalaemia, Dextrocardia, STEMI Anterior, STEMI (Lateral), Right Atrial Enlargement (RAE), STEMI (Inferior), 20, hypertrophic cardiomyopathy, 687.916, 63.561, 389.465

6

FALSE

144, **37**, **3**, NWG, 30-40, female, cardiology, 10-20, 1000s, Consent given, Chrome, Windows 9, 693.844, Regular, 104, Yes, Yes, 1693.512, 1005.60, Yes, pulmonale, 0.13, 4.51, No, 0.2, 1760.239, 66.727, 47, No, , No, , No, , No, , 1816.584, 56.345, 0.11, 0.39, 0.58, 0.51, No, , Yes, Array, No, , No, , 2011.887, 195.303, No, No, No, TRUE, FALSE, STEMI, Right Atrial Enlargement (RAE), Normal Sinus Rhythm, Bi-atrial Enlargement, STEMI (Inferior), Left Atrial Enlargement (LAE), STEMI (Lateral), STEMI Anterior, STEMI (Septal), 9, Right Atrial Enlargement (RAE),, 2052.509, 40.622, 1364.593

9

TRUE

145, **37**, **4**, NWG, 30-40, female, cardiology, 10-20, 1000s, Consent given, Chrome, Windows 10, 2057.306, Regular, 131, No, No, 2144.564, 92.05, No, other, NC, NC, No, NC, 2173.559, 28.995, -55, No, , No, , No, , No, , 2293.393, 119.834, 0.14, 0.3, 0.26, 0.59, No, , No, , No, , No, , 2410.497, 117.104, No, No, No, FALSE, FALSE, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), Atrial Flutter, 4, Ventricular Tachycardia,, 2440.272, 29.775, 387.763

8

TRUE

146, **37**, **5**, NWG, 30-40, female, cardiology, 10-20, 1000s, Consent given, Chrome, Windows 11, 2444.686, Regular, 125, No, No, 2486.316, 46.04, No, other, NC, NC, No, NC, 2500.43, 14.114, 59, No, , No, , No, , No, , 2523.245, 22.8150000000001, NC, 0.24, 0.32, 0.42, No, , No, , No, , No, , 2690.874, 167.629, No, No, No, FALSE, FALSE, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), Atrial Flutter, 4, Supraventricular Tachycardia,, 2796.671, 105.797, 356.399

10

TRUE

147, **38**, **1**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, 1, Regular, 88, Yes, Yes, 34.874, 34.87, Yes, normal, 0.08, 1.5, No, NC, 88.565, 53.691, 60, No, , No, , Yes, Array, Yes, Array, 162.353, 73.788, 0.06, 0.36, 0.72, 0.42, Yes, Array, Yes, Array, No, , No, , 271.664, 109.311, Yes, No, No, TRUE, FALSE, Poor R Wave Progression, NSTEMI, STEMI, STEMI Anterior, STEMI (Lateral), Normal Sinus Rhythm, Right Ventricular Hypertrophy (RVH), Dextrocardia, STEMI (Inferior), Chest leads placement error (V1-V5 reversal), STEMI (Septal), 11, Normal Sinus Rhythm,acute anterolateral MI, 361.15, 89.486, 361.150

8

TRUE

148, **38**, **2**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 8, 364.495, Regular, 75, Yes, Yes, 393.604, 32.45, Yes, normal, 0.08, 2, No, NC, 443.518, 49.914, 59, No, , No, , Yes, Array, Yes, Array, 483.089, 39.571, 0.08, NC, 0.88, 0.38, No, , Yes, Array, Yes, Array, Yes, Array, 607.314, 124.225, No, No, No, TRUE, FALSE, STEMI (Septal), NSTEMI, STEMI, Right Arm - Left Arm Reversal, Left Ventricular Hypertrophy (LVH), Normal Sinus Rhythm, Dextrocardia, STEMI Anterior, STEMI (Inferior), Hyperkalaemia, STEMI (Lateral), 11, Normal Sinus Rhythm,Left Ventricular Hypertrophy (LVH),strain pattern T waves, 651.167, 43.853, 290.017

8

TRUE

149, **38**, **3**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 9, 654.165, Regular, 100, Yes, Yes, 675.698, 24.53, Yes, pulmonale, NC, 5, No, 0.2, 726.642, 50.944, 89, No, , No, , No, , No, , 758.902, 32.26, 0.08, 0.28, 0.6, 0.36, No, , No, , No, , No, , 843.333, 84.4309999999999, No, No, No, TRUE, TRUE, Right Atrial Enlargement (RAE), Normal Sinus Rhythm, 2, Sinus Tachycardia,p pulmonale NSIVCD, 899.403, 56.070, 248.236

9

FALSE

150, **38**, **4**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 10, 902.303, Regular, 160, No, No, 958.92, 59.52, No, none, NC, NC, No, NC, 981.417, 22.497, -150, No, , No, , No, , No, , 1002.942, 21.525, 0.18, 0, 0.28, Adjust the QT interval, No, , No, , No, , No, , 1058.441, 55.499, Yes, No, No, FALSE, FALSE, Poor R Wave Progression, Normal Sinus Rhythm, Junctional Rhythm, Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), Chest leads placement error (V1-V5 reversal), Atrial Flutter, 7, VT, 1075.661, 17.220, 176.258

9

TRUE

151, **38**, **5**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 11, 1079.893, Regular, 160, No, No, 1120.016, 44.36, No, none, NC, NC, No, NC, 1127.81, 7.794, 59, No, , No, , Yes, Array, No, , 1161.812, 34.002, 0.06, 0.24, 0.33, 0.42, No, , No, , Yes, Array, No, , 1224.387, 62.575, Yes, No, No, FALSE, FALSE, Normal Sinus Rhythm, Second Degree AV Block Type I (Wenckebach / Mobitz I), Junctional Rhythm, Third Degree AV Block (complete heart block), NSTEMI, Atrial Flutter, Second Degree AV Block Type II (Mobitz II), 7, SVT ATRIAL FLUTTER WITH A FAST VENTRICULAR RESPONSE, 1273.377, 48.990, 197.716

9

TRUE

152, **39**, **1**, NWG, 40-50, male, Clinical Electrophysiologist, 10-20, 100s, Consent given, Chrome, Windows 7, 1, Regular, 75, Yes, Yes, 50.009, 50.01, Yes, normal, 0.11, 1.99, Yes, 0.17, 154.915, 104.906, 36, No, , No, , No, , No, , 252.781, 97.866, 0.11, 0.42, 0.88, 0.45, No, , Yes, Array, No, , Yes, Array, 427.965, 175.184, Yes, No, No, TRUE, FALSE, Poor R Wave Progression, Third Degree AV Block (complete heart block), STEMI Anterior, STEMI, Normal Sinus Rhythm, Second Degree AV Block Type I (Wenckebach / Mobitz I), Chest leads placement error (V1-V5 reversal), STEMI (Inferior), STEMI (Septal), NSTEMI, Dextrocardia, STEMI (Lateral), 12, Normal Sinus Rhythm,Poor R Wave Progression,, 607.072, 179.107, 607.072

8

FALSE

153, **39**, **2**, NWG, 40-50, male, Clinical Electrophysiologist, 10-20, 100s, Consent given, Chrome, Windows 8, 618.427, Regular, 77, Yes, Yes, 789.983, 182.91, Yes, pulmonale, 0.1, 2.89, No, 0.17, 890.229, 100.246, 71, No, , No, , No, , Yes, Array, 966.563, 76.3339999999999, 0.1, 0.48, NC, 0.51, No, , No, , No, , Yes, Array, 1095.998, 129.435, No, No, No, FALSE, FALSE, Right Atrial Enlargement (RAE), Right Arm - Left Arm Reversal, Atrial Fibrillation, Normal Sinus Rhythm, Benign Early Repolarisation (J-point elevation,high take-off), Ventricular Tachycardia, Pulmonary Embolism, NSTEMI, Dextrocardia, Hyperkalaemia, 11, Normal Sinus Rhythm,Right Atrial Enlargement (RAE),Left Ventricular Hypertrophy (LVH),Wellens Syndrome,, 1220.068, 124.070, 612.996

9

TRUE

154, **39**, **3**, NWG, 40-50, male, Clinical Electrophysiologist, 10-20, 100s, Consent given, Chrome, Windows 9, 1228.076, Regular, 110, Yes, Yes, 1272.667, 52.60, Yes, pulmonale, 0.09, 4.55, No, NC, 1366.701, 94.034, 123, No, , No, , No, , No, , 1435.384, 68.683, 0.1, 0.38, 0.52, 0.53, No, , No, , No, , No, , 1628.159, 192.775, No, No, No, TRUE, TRUE, Right Atrial Enlargement (RAE), Normal Sinus Rhythm, 2, Normal Sinus Rhythm,Bi-atrial Enlargement,, 1676.745, 48.586, 456.677

8

FALSE

155, **39**, **4**, NWG, 40-50, male, Clinical Electrophysiologist, 10-20, 100s, Consent given, Chrome, Windows 10, 1682.071, Regular, 160, Yes, No, 1829.776, 153.03, Yes, none, 0.07, 1.94, No, 0.19, 1913.288, 83.512, 94, No, , No, , No, , Yes, Array, 1968.941, 55.653, 0.18, 0.32, 0.3, 0.58, No, , No, , No, , No, , 2080.556, 111.615, No, No, No, TRUE, FALSE, Right Arm - Left Arm Reversal, Normal Sinus Rhythm, Ventricular Tachycardia, Dextrocardia, NSTEMI, 5, Ventricular Tachycardia,, 2123.015, 42.459, 446.270

9

TRUE

156, **39**, **5**, NWG, 40-50, male, Clinical Electrophysiologist, 10-20, 100s, Consent given, Chrome, Windows 11, 2129.76, Regular, 160, No, No, 2168.501, 45.49, No, none, NC, NC, No, NC, 2191.896, 23.395, 59, No, , No, , No, , No, , 2231.961, 40.0649999999996, NC, 0.26, 0.32, 0.46, No, , No, , No, , No, , 2309.554, 77.5930000000003, No, No, No, FALSE, FALSE, Normal Sinus Rhythm, Junctional Rhythm, Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), Atrial Flutter, 5, Supraventricular Tachycardia,, 2371.228, 61.674, 248.213

10

TRUE

157, **40**, **1**, faelvenn, 30-40, male, Cardiology fellow, <10, 100s, Consent given, Chrome, Unknown OS Platform, 1, Regular, 95, Yes, Yes, 28.342, 28.34, Yes, normal, 0.08, 1.9, No, NC, 97.163, 68.821, 60, No, , No, , No, , No, , 220.409, 123.246, NC, 0.38, 0.75, 0.44, No, , Yes, Array, No, , No, , 499.052, 278.643, Yes, No, No, TRUE, FALSE, Poor R Wave Progression, STEMI, Normal Sinus Rhythm, STEMI (Lateral), STEMI (Septal), Chest leads placement error (V1-V5 reversal), STEMI Anterior, STEMI (Inferior), 8, STEMI LATERAL, 1117.015, 617.963, 1117.015

6

TRUE

158, **40**, **2**, faelvenn, 30-40, male, Cardiology fellow, <10, 100s, Consent given, Chrome, Unknown OS Platform, 1123.166, Regular, NC, Yes, Yes, 1147.96, 30.94, Yes, pulmonale, 0.1, 2.91, No, 0.15, 1210.28, 62.320, 56, No, , No, , No, , Yes, Array, 1292.534, 82.2540000000001, 0.1, NC, 0.85, 0.41, No, , No, , Yes, Array, Yes, Array, 1388.139, 95.6049999999998, No, No, No, FALSE, FALSE, NSTEMI, Right Atrial Enlargement (RAE), Right Arm - Left Arm Reversal, Atrial Fibrillation, Benign Early Repolarisation (J-point elevation,high take-off), Ventricular Tachycardia, Normal Sinus Rhythm, Pulmonary Embolism, Myocardial Ischaemia, Right Ventricular Hypertrophy (RVH), Digoxin Effect, Dextrocardia, Hyperkalaemia, Hypokalaemia, 15, Apical HCM, 1472.645, 84.506, 355.630

7

FALSE

159, **40**, **3**, faelvenn, 30-40, male, Cardiology fellow, <10, 100s, Consent given, Chrome, Unknown OS Platform, 1476.353, Regular, 101, Yes, Yes, 1749.787, 277.14, Yes, pulmonale, NC, 4.5, No, 0.17, 1799.451, 49.664, 104, No, , No, , No, , Yes, Array, 1938.288, 138.837, NC, 0.39, 0.6, 0.5, No, , No, , No, , No, , 2234.509, 296.221, No, No, No, TRUE, TRUE, Right Atrial Enlargement (RAE), Normal Sinus Rhythm, NSTEMI, 3, Right atrial enlargement - QTc prolongation, 2294.726, 60.217, 822.081

6

TRUE

160, **40**, **4**, faelvenn, 30-40, male, Cardiology fellow, <10, 100s, Consent given, Chrome, Unknown OS Platform, 2300.263, Regular, 160, Yes, No, 2573.042, 278.32, No, flutter, 0.08, 1.3, No, NC, 2632.301, 59.259, 131, No, , No, , No, , No, , 2741.146, 108.845, 0.15, 0.26, 0.33, 0.45, No, , No, , No, , No, , 2925.541, 184.395, Yes, No, No, FALSE, FALSE, Atrial Flutter, Poor R Wave Progression, Normal Sinus Rhythm, Chest leads placement error (V1-V5 reversal), 4, Ventricular Tachycardia,, 3109.653, 184.112, 814.927

7

TRUE

161, **40**, **5**, faelvenn, 30-40, male, Cardiology fellow, <10, 100s, Consent given, Chrome, Unknown OS Platform, 3113.208, Regular, 160, Yes, No, 6244.099, 3134.45, No, none, NC, NC, No, NC, 6755.744, 511.645, 70, No, , No, , No, , No, , 6774.422, 18.6779999999999, NC, 0.24, 0.35, 0.41, No, , No, , No, , No, , 6836.3, 61.8780000000006, Yes, No, No, FALSE, FALSE, Normal Sinus Rhythm, Atrial Flutter, 2, Narrow QRS tachycardia, possibly typical AVNRT, 6897.829, 61.529, 3788.176

8

TRUE

162, **42**, **6**, WG, 30-40, male, Cardiology, <10, 1000s, Consent given, Firefox, Windows 7, 1, Not regular, NC, No, No, 61.678, 61.68, No, fibrillation, NC, NC, No, NC, 93.269, 31.591, 132, No, , No, , No, , No, , 342.117, 248.848, NC, NC, NC, , No, , No, , No, , No, , 389.444, 47.327, No, No, No, FALSE, FALSE, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), Atrial Flutter, 4, Atrial Fibrillation,, 478.797, 89.353, 478.797

NC

TRUE

163, **42**, **7**, WG, 30-40, male, Cardiology, <10, 1000s, Consent given, Firefox, Windows 7, 480.845, Not regular, NC, No, No, 497.848, 19.05, Yes, normal, NC, NC, No, NC, 521.263, 23.415, 89, No, , No, , No, , No, , 561.946, 40.683, NC, NC, NC, , No, , No, , No, , No, , 568.94, 6.99400000000003, No, No, Yes, FALSE, FALSE, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), 3, Normal Sinus Rhythm,, 657.202, 88.262, 178.405

NC

FALSE

164, **42**, **8**, WG, 30-40, male, Cardiology, <10, 1000s, Consent given, Firefox, Windows 7, 658.413, Not regular, NC, No, No, 668.471, 11.27, Yes, normal, NC, NC, No, NC, 687.223, 18.752, 90, No, , No, , No, , No, , 707.43, 20.207, NC, NC, NC, , No, , No, , No, , No, , 713.069, 5.63900000000001, No, No, Yes, FALSE, FALSE, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), 3, Chest leads placement error (V1-V5 reversal),, 737.904, 24.835, 80.702

NC

FALSE

165, **42**, **9**, WG, 30-40, male, Cardiology, <10, 1000s, Consent given, Firefox, Windows 7, 739.393, Not regular, NC, No, No, 745.128, 7.22, Yes, mitrale, NC, NC, No, NC, 759.226, 14.098, -7, No, , No, , No, , No, , 775.944, 16.718, NC, NC, NC, , No, , No, , No, , No, , 779.797, 3.85300000000007, No, Yes, No, TRUE, FALSE, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), Left Atrial Enlargement (LAE), Chest leads placement error (V1-V5 reversal), 5, Chest leads placement error (V1-V5 reversal),, 798.294, 18.497, 60.390

NC

TRUE

166, **42**, **10**, WG, 30-40, male, Cardiology, <10, 1000s, Consent given, Firefox, Windows 7, 799.752, Not regular, 80, No, No, 805.567, 7.27, Yes, normal, 0.12, 2.5, No, 0.16, 816.029, 10.462, 0, No, , No, , No, , No, , 826.601, 10.572, 0.09, 0.4, 1, , No, , No, , No, , No, , 830.589, 3.98800000000006, No, No, No, TRUE, TRUE, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), 3, Normal Sinus Rhythm,, 841.775, 11.186, 43.481

5

TRUE

167, **43**, **1**, WG, 30-40, male, Cardiology Fellow & Research Manager, <10, 1000s, Consent given, Chrome, Unknown OS Platform, USER NOT FINISHED YET, Regular, 84, Yes, Yes, 480.584, 480.58, Yes, normal, 0.08, 0.1, No, NC, 682.404, 201.820, 60, No, , No, , No, , No, , 2273.518, 1591.114, 0.08, NC, 0.68, Adjust the QT interval, No, , Yes, Array, No, , No, , 2967.069, 693.551, Yes, Yes, No, TRUE, FALSE, Poor R Wave Progression, STEMI Anterior, Chest leads placement error (V1-V5 reversal), STEMI, Normal Sinus Rhythm, STEMI (Septal), STEMI (Inferior), STEMI (Lateral), 8, This patient has a normal sinus rhythm, at heart rate of 83 BPM. ST segment elevation V3-5, with poor R-Wave progression in chest leads, which may be either due to Anterior STEMI or misplaced chest leads., 3452.558, 485.489, 3452.558

6

TRUE

168, **45**, **7**, WG, 40-50, male, Biomed Eng, <10, 10s, Consent given, Chrome, Windows 7, 923.904, Regular, 55, Yes, Yes, 2703.751, , Yes, normal, 0.15, 1.01, No, 0.2, 2914.404, 210.653, 179, No, , No, , Yes, Array, No, , 2982.888, 68.4839999999999, 0.08, 0.32, 0.85, 0.35, No, , No, , No, , No, , 3077.604, 94.7159999999999, No, No, No, FALSE, FALSE, Sinus Bradycardia, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), Left Atrial Enlargement (LAE), NSTEMI, 5, Normal Sinus Rhythm,, 3107.693, 30.089, 3107.693

8

FALSE

169, **45**, **8**, WG, 40-50, male, Biomed Eng, <10, 10s, Consent given, Chrome, Windows 7, 3111.3, Not regular, NC, No, No, 3191.904, 84.21, No, fibrillation, NC, NC, No, NC, 3211.649, 19.745, 0, Yes, Array, No, , No, , No, , 3263.977, 52.328, 0.14, 0.26, 0.72, 0.31, No, , Yes, Array, No, , No, , 3389.359, 125.382, No, No, No, FALSE, FALSE, Second Degree AV Block Type II (Mobitz II), STEMI, Sinus Tachycardia, Normal Sinus Rhythm, Junctional Rhythm, Atrial Flutter, STEMI Anterior, STEMI (Lateral), STEMI (Inferior), STEMI (Septal), Third Degree AV Block (complete heart block), 11, Second Degree AV Block Type II (Mobitz II),, 3505.951, 116.592, 398.258

NC

FALSE

170, **45**, **9**, WG, 40-50, male, Biomed Eng, <10, 10s, Consent given, Chrome, Windows 7, 3507.845, Not regular, 67, Yes, Yes, 3572.619, 66.67, Yes, mitrale, NC, 1.11, No, 0.14, 3697.259, 124.640, 94, No, , No, , No, , No, , 3726.461, 29.2019999999998, 0.11, 0.36, 0.9, 0.38, No, , No, , No, , No, , 3801.931, 75.4700000000003, No, No, No, FALSE, FALSE, Sinus Tachycardia, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), Left Atrial Enlargement (LAE), 4, Left Atrial Enlargement (LAE),, 3841.449, 39.518, 335.498

6

FALSE

171, **45**, **10**, WG, 40-50, male, Biomed Eng, <10, 10s, Consent given, Chrome, Windows 7, 3845.894, Regular, 83, Yes, Yes, 3900.515, 59.07, Yes, mitrale, 0.2, 1.1, No, 0.16, 3991.574, 91.059, 0, No, , No, , No, , No, , 4015.01, 23.4360000000001, 0.12, 0.34, 1.06, 0.33, No, , No, , No, , No, , 4094.847, 79.837, Yes, No, No, TRUE, FALSE, Left Atrial Enlargement (LAE), Sinus Tachycardia, Normal Sinus Rhythm, Bi-atrial Enlargement, Second Degree AV Block Type II (Mobitz II), 5, Left Atrial Enlargement (LAE),, 4131.184, 36.337, 289.735

6

FALSE

173, **49**, **1**, 1, 30-40, male, Assistant Professor of Nursing, <10, 10s, Consent given, Chrome, Unknown OS Platform, 1, Regular, 91, Yes, Yes, 95.937, 95.94, Yes, normal, 0.08, 2.01, No, NC, 191.025, 95.088, 60, No, , No, , No, , No, , 286.427, 95.402, NC, NC, 0.75, Adjust the QT interval, No, , Yes, Array, No, , No, , 442.609, 156.182, No, No, No, TRUE, TRUE, STEMI, Normal Sinus Rhythm, STEMI Anterior, STEMI (Lateral), STEMI (Inferior), STEMI (Septal), 6, Normal sinus rhythm with anterior wall STEMI, 556.717, 114.108, 556.717

9

TRUE

174, **49**, **2**, 1, 30-40, male, Assistant Professor of Nursing, <10, 10s, Consent given, Chrome, Unknown OS Platform, 566.595, Regular, 69, Yes, Yes, 607.863, 51.15, Yes, normal, NC, NC, No, 0.13, 655.363, 47.500, 47, No, , No, , No, , Yes, Array, 1084.878, 429.515, NC, NC, 0.87, Adjust the QT interval, No, , No, , Yes, Array, Yes, Array, 1166.838, 81.96, No, No, No, FALSE, FALSE, NSTEMI, Normal Sinus Rhythm, Right Arm - Left Arm Reversal, Hyperkalaemia, Dextrocardia, 5, Left Ventricular Hypertrophy (LVH),, 1262.765, 95.927, 706.048

9

TRUE

175, **49**, **3**, 1, 30-40, male, Assistant Professor of Nursing, <10, 10s, Consent given, Chrome, Unknown OS Platform, 1267.085, Regular, 101, Yes, Yes, 1298.296, 35.53, Yes, mitrale, NC, 4.79, No, NC, 1377.408, 79.112, 90, No, , No, , No, , No, , 1450.663, 73.2550000000001, 0.11, 0.44, 0.55, 0.59, No, , No, , No, , No, , 1512.221, 61.558, No, No, No, TRUE, FALSE, Normal Sinus Rhythm, Bi-atrial Enlargement, Left Atrial Enlargement (LAE), Right Atrial Enlargement (RAE), 4, Right Atrial Enlargement (RAE),Right Ventricular Hypertrophy (RVH),, 1588.058, 75.837, 325.293

7

TRUE

176, **49**, **4**, 1, 30-40, male, Assistant Professor of Nursing, <10, 10s, Consent given, Chrome, Unknown OS Platform, 1593.922, Not regular, 160, Yes, No, 1679.674, 91.62, No, fibrillation, NC, NC, No, NC, 1699.618, 19.944, 91, No, , No, Array, No, , No, Array, 1803.132, 103.514, 0.16, 0.26, 0.35, 0.44, No, , No, , No, , No, , 1901.139, 98.0069999999998, No, No, No, TRUE, FALSE, Normal Sinus Rhythm, Atrial Fibrillation, Atrial Flutter, Ventricular Tachycardia, 4, Supraventricular Tachycardia,Left Bundle Branch Block (LBBB),, 1968.826, 67.687, 380.768

7

FALSE

177, **49**, **5**, 1, 30-40, male, Assistant Professor of Nursing, <10, 10s, Consent given, Chrome, Unknown OS Platform, 1971.39, Not regular, 160, No, No, 2015.154, 46.33, No, none, NC, NC, No, NC, 2021.782, 6.628, 48, No, , No, , No, , No, , 2038.054, 16.2720000000002, NC, NC, NC, , No, , No, , No, , No, , 2049.88, 11.826, Yes, No, No, FALSE, FALSE, Normal Sinus Rhythm, Junctional Rhythm, Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), Atrial Flutter, 5, PSVT, 2105.07, 55.190, 136.244

8

TRUE

178, **50**, **1**, DEL, 40-50, male, cardiologist, 20-30, 1000s, Consent given, Chrome, Windows 7, 1, Regular, NC, Yes, Yes, 61.262, 61.26, Yes, normal, 0.08, 1.81, No, NC, 166.697, 105.435, 57, No, , Yes, Array, Yes, Array, No, , 251.028, 84.331, NC, NC, NC, , No, , Yes, Array, No, , No, , 331.663, 80.635, No, No, No, TRUE, TRUE, STEMI, STEMI Anterior, STEMI (Lateral), Normal Sinus Rhythm, STEMI (Inferior), STEMI (Septal), NSTEMI, 7,

STEMI,STEMI (Lateral),Normal Sinus Rhythm,, 512.483, 180.820, 512.483
6

TRUE

179, **50**, **2**, DEL, 40-50, male, cardiologist, 20-30, 1000s, Consent given, Chrome, Windows 8, 523.004, Regular, 72, Yes, Yes, 558.439, 45.96, Yes, normal, NC, 2.02, No, NC, 627.588, 69.149, 56, No, , No, , No, , Yes, Array, 728.269, 100.681, NC, 0.44, 0.85, 0.48, No, , No, , Yes, Array, Yes, Array, 916.93, 188.661, No, No, No, FALSE, FALSE, NSTEMI, Atrial Fibrillation, Benign Early Repolarisation (J-point elevation,high take-off), Ventricular Tachycardia, Right Arm - Left Arm Reversal, Normal Sinus Rhythm, Myocardial Ischaemia, Digoxin Effect, Pulmonary Embolism, Hypokalaemia, Hyperkalaemia, Dextrocardia, 13, Left Ventricular Hypertrophy (LVH),Myocardial Ischaemia,Digoxin Effect,, 1071.823, 154.893, 559.340
8

TRUE

180, **50**, **3**, DEL, 40-50, male, cardiologist, 20-30, 1000s, Consent given, Chrome, Windows 9, 1079.144, Regular, 96, Yes, Yes, 1144.21, 72.39, Yes, pulmonale, NC, 3.57, No, NC, 1262.417, 118.207, 103, No, , No, , No, , Yes, Array, 1360.724, 98.307, 0.1, 0.36, 0.6, 0.46, No, , No, , No, , No, , 1519.052, 158.328, No, No, No, TRUE, TRUE, Right Atrial Enlargement (RAE), Normal Sinus Rhythm, NSTEMI, 3, Right Atrial Enlargement (RAE),Normal Sinus Rhythm,, 1558.527, 39.475, 486.704
9

TRUE

181, **50**, **4**, DEL, 40-50, male, cardiologist, 20-30, 1000s, Consent given, Chrome, Windows 10, 1563.447, Regular, 160, No, No, 1699.598, 141.07, No, fibrillation, NC, NC, No, NC, 1729.519, 29.921, 147, No, , No, , No, , No, , 1834.551, 105.032, 0.17, 0.32, 0.29, 0.59, No, , No, , No, , No, , 1975.915, 141.364, Yes, No, No, FALSE, FALSE, Poor R Wave Progression, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), Chest leads placement error (V1-V5 reversal), Atrial Flutter, 6, Ventricular Tachycardia,, 2036.791, 60.876, 478.264
9

TRUE

182, **50**, **5**, DEL, 40-50, male, cardiologist, 20-30, 1000s, Consent given, Chrome, Windows 11, 2041.872, Regular, 160, No, No, 2166.281, 129.49, No, none, NC, NC, No, NC, 2181.481, 15.200, 70, No, , No, , No, , No, , 2235.949, 54.4679999999998, NC, 0.25, 0.32, 0.44, No, , No, , No, , No, , 2294.433, 58.4839999999999, Yes, No, No, FALSE, FALSE, Normal Sinus Rhythm, Junctional Rhythm, Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), Atrial Flutter, 5, Supraventricular Tachycardia,avnrt, 2343.637, 49.204, 306.846
8

TRUE

183, **52**, **6**, NWG, 40-50, male, Consultant, 20-30, 1000s, Consent given, Chrome, Unknown OS Platform, 1, Not regular, 160, No, No, 841.028, 841.03, No, fibrillation, NC, NC, No, NC, 861.947, 20.919, 113, No, , No, Array, No, Array, No, Array, 877.197, 15.25, 0.16, 0.26, 0.36, 0.43, No, , No, , No, Array, No, Array, 893.207, 16.01, Yes, No, No, TRUE, FALSE, Second Degree AV Block Type II (Mobitz II), Sinus Tachycardia, Poor R Wave Progression, Right Bundle Branch Block (RBBB), Pulmonary Embolism, Right Ventricular Hypertrophy (RVH), Left Bundle Branch Block (LBBB), Atrial Fibrillation, Ventricular Tachycardia, Junctional Rhythm, Supraventricular Tachycardia, Myocardial Ischaemia, Digoxin Effect, Third Degree AV Block (complete heart block), STEMI (Lateral), Atrial Flutter, Chest leads placement error (V1-V5 reversal), Hyperkalaemia, Hypokalaemia, 19, Preexcited atrial fibrillation, 946.856, 53.649, 946.856
10

TRUE

184, **52**, **7**, NWG, 40-50, male, Consultant, 20-30, 1000s, Consent given, Chrome, Unknown OS Platform, 952.401, Regular, 72, Yes, Yes, 998.191, 51.34, Yes, normal, 0.14, 2, No, 0.2, 1110.421, 112.230, 169, Yes, Array, No, , No,

, Yes, Array, 1273.879, 163.458, NC, 0.38, 0.84, 0.41, No, , No, , No, , No, , 1395.421, 121.542, No, No, Yes, TRUE, FALSE, Sinus Tachycardia, Right Arm - Left Arm Reversal, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), NSTEMI, Left Atrial Enlargement (LAE), Dextrocardia, 7, Right Arm - Left Arm Reversal,, 1448.613, 53.192, 501.757

10

TRUE

185, **52**, **8**, NWG, 40-50, male, Consultant, 20-30, 1000s, Consent given, Chrome, Unknown OS Platform, 1453.319, Regular, 88, Yes, Yes, 1504.034, 55.42, Yes, normal, NC, 1.51, No, 0.2, 1578.551, 74.517, -157, Yes, Array, No, , No, , Yes, Array, 1687.704, 109.153, 0.11, 0.39, 0.7, 0.47, No, , No, , No, , Yes, Array, 1853.872, 166.168, Yes, Yes, Yes, TRUE, FALSE, Sinus Tachycardia, Poor R Wave Progression, Right Arm - Left Arm Reversal, Chest leads placement error (V1-V5 reversal), Dextrocardia, Hyperkalaemia, Left Bundle Branch Block (LBBB), Normal Sinus Rhythm, Ventricular Tachycardia, Atrial Fibrillation, Second Degree AV Block Type II (Mobitz II), NSTEMI, 12, Dextrocardia,, 1896.743, 42.871, 448.130

8

TRUE

186, **52**, **9**, NWG, 40-50, male, Consultant, 20-30, 1000s, Consent given, Chrome, Unknown OS Platform, 1900.194, Regular, 70, Yes, Yes, 1949.406, 52.66, Yes, mitrale, 0.14, 2.24, No, 0.21, 2033.679, 84.273, 58, No, , No, , No, , No, , 2070.504, 36.8249999999998, 0.1, 0.42, 0.85, 0.46, No, , No, , No, , No, , 2175.893, 105.389, Yes, No, No, TRUE, FALSE, Sinus Tachycardia, Left Atrial Enlargement (LAE), Poor R Wave Progression, Normal Sinus Rhythm, Left Bundle Branch Block (LBBB), Bi-atrial Enlargement, Second Degree AV Block Type II (Mobitz II), Chest leads placement error (V1-V5 reversal), 8, Left Atrial Enlargement (LAE),Right Ventricular Hypertrophy (RVH),, 2202.056, 26.163, 305.313

8

FALSE

187, **52**, **10**, NWG, 40-50, male, Consultant, 20-30, 1000s, Consent given, Chrome, Unknown OS Platform, 2207.025, Not regular, 68, Yes, Yes, 2264.76, 62.70, Yes, normal, 0.12, 1.74, No, 0.16, 2307.366, 42.606, 66, Yes, Array, No, , No, , No, , 2370.323, 62.9569999999999, 0.1, 0.4, 1, 0.42, No, , No, , No, , No, , 2444.37, 74.047, Yes, No, No, TRUE, FALSE, Sinus Tachycardia, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), 3, Normal Sinus Rhythm,, 2476.119, 31.749, 274.063

5

TRUE

188, **53**, **6**, ecg1, 30-40, female, researcher, <10, 10s, Consent given, Firefox, Windows 8.1, USER NOT FINISHED YET, Not regular, 160, No, No, 383.315, 383.32, No, fibrillation, NC, NC, No, NC, 400.875, 17.560, 128, No, Array, Yes, Array, Yes, Array, No, , 797.622, 396.747, 0.12, 0.29, 0.32, 0.51, Yes, Array, No, , Yes, Array, No, , 1215.946, 418.324, Yes, No, No, FALSE, FALSE, Second Degree AV Block Type II (Mobitz II), STEMI, STEMI (Lateral), Sinus Tachycardia, Poor R Wave Progression, Left Bundle Branch Block (LBBB), Junctional Rhythm, Normal Sinus Rhythm, Third Degree AV Block (complete heart block), STEMI Anterior, STEMI (Inferior), STEMI (Septal), NSTEMI, Atrial Flutter, Chest leads placement error (V1-V5 reversal), 15, NSTEMI, 1359.129, 143.183, 1359.129

NC

FALSE

189, **53**, **7**, ecg2, 30-40, female, researcher, <10, 10s, Consent given, Firefox, Windows 8.2, USER NOT FINISHED YET, Regular, 76, No, Yes, 1422.703, 63.57, Yes, normal, NC, 2, No, 0.26, 1638.653, 215.950, -170, Yes, Array, No, , No, , No, , 1762.276, 123.623, NC, NC, NC, , No, , No, , No, , No, , 1915.714, 153.438, No, No, No, FALSE, FALSE, Second Degree AV Block Type II (Mobitz II), Sinus Tachycardia, Normal Sinus Rhythm, Third Degree AV Block (complete heart block), 4, third degree av block , 2049.769, 134.055, 690.640

NC

FALSE

190, **53**, **8**, ecg3, 30-40, female, researcher, <10, 10s, Consent given, Firefox, Windows 8.3, USER NOT FINISHED

YET, Not regular, NC, No, No, 2054.784, 5.02, No, none, NC, NC, No, NC, 2064.312, 9.528, 100, Yes, Array, No, , No, , No, , No, , 2114.552, 50.2400000000002, 0.12, 0.36, 0.8, 0.4, No, , No, , No, , No, , 2187.455, 72.9029999999998, Yes, No, No, FALSE, FALSE, Second Degree AV Block Type II (Mobitz II), Sinus Tachycardia, Poor R Wave Progression, Junctional Rhythm, Normal Sinus Rhythm, Left Bundle Branch Block (LBBB), Third Degree AV Block (complete heart block), Atrial Flutter, Chest leads placement error (V1-V5 reversal), 9, junctional rhythm, 2296.742, 109.287, 246.973

NC

FALSE

191, **53**, **9**, ecg4, 30-40, female, researcher, <10, 10s, Consent given, Firefox, Windows 8.4, USER NOT FINISHED YET, Regular, 67, Yes, Yes, 2330.062, 33.32, Yes, normal, NC, 2, No, 0.13, 2360.797, 30.735, 28, No, , No, , No, , No, , 2379.581, 18.7840000000001, 0.1, 0.48, 0.8, 0.54, No, , No, , No, , No, , 2418.381, 38.7999999999997, No, No, No, FALSE, FALSE, Sinus Tachycardia, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), 3, NSR, 2439.212, 20.831, 142.470

NC

FALSE

192, **54**, **1**, UCSF, >60, female, Professor of Nursing, 20-30, 10s, Consent given, Unknown Browser, Windows 7, USER NOT FINISHED YET, Regular, 88, Yes, Yes, 138.666, 138.67, Yes, normal, 0.08, 0.15, No, NC, 395.149, 256.483, 60, No, , No, , No, , No, , 507.912, 112.763, 0.08, 0.36, 0.7, 0.43, Yes, Array, Yes, Array, No, , No, , 969.333, 461.421, No, No, No, TRUE, TRUE, STEMI, Normal Sinus Rhythm, STEMI Anterior, STEMI (Lateral), STEMI (Inferior), STEMI (Septal), 6, Normal Sinus Rhythm,Poor R Wave Progression,STEMI (Lateral),, 1360.655, 391.322, 1360.655

NC

TRUE

193, **54**, **2**, UCSF, >60, female, Professor of Nursing, 20-30, 10s, Consent given, Unknown Browser, Windows 8, USER NOT FINISHED YET, Regular, 71, Yes, Yes, 1477.354, 116.70, Yes, normal, 0.1, 0.25, No, 0.14, 1702.14, 224.786, 51, Yes, Array, No, , No, , Yes, Array, 1851.463, 149.323, 0.1, 0.44, 0.85, 0.48, Yes, Array, No, , No, , Yes, Array, 2148.796, 297.333, No, No, No, FALSE, FALSE, Right Arm - Left Arm Reversal, Normal Sinus Rhythm, Benign Early Repolarisation (J-point elevation,high take-off), Wellens Syndrome, Atrial Fibrillation, NSTEMI, Ventricular Tachycardia, Dextrocardia, Hyperkalaemia, 10, Normal Sinus Rhythm,Left Ventricular Hypertrophy (LVH),, 2183.852, 35.056, 823.197

7

TRUE

194, **54**, **3**, UCSF, >60, female, Professor of Nursing, 20-30, 10s, Consent given, Unknown Browser, Windows 9, USER NOT FINISHED YET, Regular, 100, Yes, Yes, 2247.928, 64.08, Yes, pulmonale, NC, 0.5, No, NC, 2491.299, 243.371, 90, No, , No, , No, , No, , 2624.353, 133.054, 0.1, 0.38, 0.56, 0.51, No, , No, , No, , No, , 2852.474, 228.121, No, No, No, TRUE, FALSE, Normal Sinus Rhythm, Right Atrial Enlargement (RAE), Normal Sinus Rhythm, Right Atrial Enlargement (RAE), Normal Sinus Rhythm, Right Atrial Enlargement (RAE), Normal Sinus Rhythm, Right Atrial Enlargement (RAE), 8, Sinus Tachycardia,Bi-atrial Enlargement,QT prolongation, 2944.319, 91.845, 760.467

7

FALSE

195, **55**, **7**, DEL, 40-50, male, EP, 20-30, 1000s, Consent given, Unknown Browser, Windows 7, 588.958, Regular, 73, Yes, Yes, 913.061, , Yes, none, 0.1, 1.99, No, 0.2, 916.596, 3.535, 180, No, , No, , No, , Yes, Array, 918.724, 2.12800000000004, 0.08, NC, 0.84, 0.39, No, , No, , No, , No, , 983.96, 65.236, Yes, No, Yes, TRUE, FALSE, Sinus Tachycardia, Poor R Wave Progression, Right Arm - Left Arm Reversal, Dextrocardia, Normal Sinus Rhythm, Left Bundle Branch Block (LBBB), Second Degree AV Block Type II (Mobitz II), NSTEMI, Chest leads placement error (V1-V5 reversal), 9, limb lead displacement, 1009.263, 25.303, 1009.263

10

TRUE

196, **55**, **8**, DEL, 40-50, male, EP, 20-30, 1000s, Consent given, Unknown Browser, Windows 8, 1012.519, Regular, 83, Yes, Yes, 1056.827, 47.56, Yes, normal, 0.06, 1.28, No, NC, 1129.047, 72.220, 162, No, , No, , No, , Yes, Array, 1227.416, 98.3689999999999, 0.1, NC, 0.72, 0.42, No, , Yes, Array, No, , Yes, Array, 1308.418, 81.002, No, No, No, FALSE, FALSE, STEMI, Sinus Tachycardia, Hyperkalaemia, Normal Sinus Rhythm, Right Arm - Left Arm Reversal, Second Degree AV Block Type II (Mobitz II), STEMI Anterior, STEMI (Lateral), STEMI (Inferior), STEMI (Septal), NSTEMI, Ventricular Tachycardia, Dextrocardia, Benign Early Repolarisation (J-point elevation,high take-off), 15, non-specific T waves changes in chest leads, 1563.554, 255.136, 554.291

8

FALSE

197, **55**, **9**, DEL, 40-50, male, EP, 20-30, 1000s, Consent given, Unknown Browser, Windows 9, 1567.802, Regular, 66, Yes, Yes, 1604.353, 40.80, Yes, mitrale, 0.09, 2.01, No, 0.2, 1662.006, 57.653, 75, No, , No, , No, Array, Yes, Array, 1719.98, 57.9739999999999, 0.08, NC, 0.84, 0.39, No, , No, , No, , No, , 1760.658, 40.6779999999999, Yes, No, No, TRUE, FALSE, Sinus Tachycardia, Poor R Wave Progression, Dextrocardia, Left Bundle Branch Block (LBBB), Right Arm - Left Arm Reversal, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), Myocardial Ischaemia, NSTEMI, Ventricular Tachycardia, Left Atrial Enlargement (LAE), Chest leads placement error (V1-V5 reversal), 12, non-specific T waves morphology in the limb leads, otherwise normal, 1810.656, 49.998, 247.102

10

FALSE

198, **55**, **10**, DEL, 40-50, male, EP, 20-30, 1000s, Consent given, Unknown Browser, Windows 10, 1815.503, Not regular, 65, Yes, Yes, 1848.198, 37.54, Yes, normal, 0.11, 1.89, No, 0.18, 1899.972, 51.774, 45, Yes, Array, No, , No, Array, Yes, Array, 1955.497, 55.5250000000001, 0.1, 0.4, 0.96, 0.36, No, , No, , No, , No, , 2035.447, 79.9499999999998, Yes, No, No, TRUE, FALSE, Sinus Tachycardia, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), NSTEMI, 4, normal ECG, 2064.438, 28.991, 253.782

10

TRUE

199, **56**, **6**, ECG, <30, female, FY1, <10, 10s, Consent given, Chrome, Mac OS X, USER NOT FINISHED YET, Regular, 160, No, No, 75.566, 75.57, No, none, NC, NC, No, NC, 91.24, 15.674, -89, No, , No, , Yes, Array, No, , 274.453, 183.213, 0.15, 0.32, 0.32, 0.57, No, , Yes, Array, Yes, Array, No, , 441.479, 167.026, Yes, No, No, FALSE, FALSE, Poor R Wave Progression, Second Degree AV Block Type II (Mobitz II), Sinus Tachycardia, STEMI, STEMI (Septal), Junctional Rhythm, Left Bundle Branch Block (LBBB), Normal Sinus Rhythm, STEMI (Lateral), STEMI Anterior, NSTEMI, Chest leads placement error (V1-V5 reversal), Atrial Flutter, STEMI (Inferior), Third Degree AV Block (complete heart block), 15, Ventricular Tachycardia,, 674.011, 232.532, 674.011

8

FALSE

200, **56**, **7**, ECG, <30, female, FY2, <10, 10s, Consent given, Chrome, Mac OS X, USER NOT FINISHED YET, Regular, 75, Yes, No, 744.205, 70.19, Yes, normal, 0.08, 0.1, No, 0.21, 844.205, 100.000, -154, Yes, Array, No, , No, , No, , 927.771, 83.5659999999999, 0.12, 0.36, NC, 0.64, No, , No, , No, , No, , 999.724, 71.9530000000001, No, No, No, FALSE, FALSE, Sinus Tachycardia, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), 3, First Degree AV Block,, 1014.849, 15.125, 340.838

9

FALSE

201, **56**, **8**, ECG, <30, female, FY3, <10, 10s, Consent given, Chrome, Mac OS X, USER NOT FINISHED YET, Not regular, 74, No, No, 1065.692, 50.84, Yes, normal, 0.04, 0.51, No, NC, 2571.044, 1505.352, -119, Yes, Array, No, , No, , Yes, Array, 2653.065, 82.0210000000002, 0.08, NC, 0.68, 0.44, No, , Yes, Array, No, , No, , 2917.098, 264.033, Yes, No, No, TRUE, FALSE, Second Degree AV Block Type II (Mobitz II), Poor R Wave Progression, STEMI, Sinus Tachycardia, Dextrocardia, Left Bundle Branch Block (LBBB), Right Arm - Left Arm Reversal, Normal

Sinus Rhythm, Third Degree AV Block (complete heart block), STEMI (Lateral), STEMI (Septal), NSTEMI, STEMI Anterior, Chest leads placement error (V1-V5 reversal), STEMI (Inferior), 15, Right Arm - Left Arm Reversal,, 3045.789, 128.691, 2030.940

2

FALSE

221, **57**, **6**, Ecg , <30, male, Gpst2, <10, 10s, Consent given, Handheld Browser, iPhone, USER NOT FINISHED YET, Regular, 146, No, No, 273.15, 273.15, No, none, NC, NC, No, NC, 290.638, 17.488, 130, No, , Yes, Array, Yes, Array, No, , 511.471, 220.833, 0.1, 0.27, 0.29, 0.5, No, , No, , Yes, Array, Yes, Array, 706.315, 194.844, No, No, No, FALSE, FALSE, STEMI, NSTEMI, Sinus Tachycardia, Normal Sinus Rhythm, Junctional Rhythm, Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), STEMI Anterior, STEMI (Lateral), STEMI (Inferior), STEMI (Septal), Atrial Flutter, 12, ?, 781.155, 74.840, 781.155

NC

FALSE

203, **59**, **6**, ecg1, <30, female, student, <10, 10s, Consent given, Safari, Mac OS X, USER NOT FINISHED YET, Regular, 120, Yes, Yes, 98.22, 98.22, No, fibrillation, NC, NC, No, NC, 124.081, 25.861, 0, No, , No, , No, , No, , 164.768, 40.687, 0.16, NC, NC, , No, , No, , No, , No, , 190.877, 26.109, No, No, No, FALSE, FALSE, Sinus Tachycardia, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), Atrial Flutter, 4, nlp, 213.455, 22.578, 213.455

NC

FALSE

206, **60**, **6**, 1111, <30, male, Stage5MBBS, <10, 10s, Consent given, Chrome, Unknown OS Platform, USER NOT FINISHED YET, Not regular, 160, No, No, 58.251, 58.25, Yes, normal, 0.1, 2.03, No, 0.2, 171.174, 112.923, 0, No, , Yes, Array, No, , No, , 370.315, 199.141, 0.12, 0.3, 0.4, 0.47, No, , No, , Yes, Array, No, , 581.498, 211.183, No, No, No, FALSE, FALSE, STEMI (Inferior), Sinus Tachycardia, STEMI, Second Degree AV Block Type II (Mobitz II), Normal Sinus Rhythm, Right Bundle Branch Block (RBBB), STEMI (Lateral), STEMI Anterior, STEMI (Septal), NSTEMI, Third Degree AV Block (complete heart block), 11, STEMI,, 691.539, 110.041, 691.539

1

FALSE

207, **60**, **7**, 1111, <30, male, Stage5MBBS, <10, 10s, Consent given, Chrome, Unknown OS Platform, USER NOT FINISHED YET, Regular, 72, Yes, Yes, 763.067, 71.53, Yes, biphasic, 0.1, 1.35, No, 0.25, 803.614, 40.547, 27, No, , No, , No, , Yes, Array, 873.732, 70.1179999999999, 0.1, NC, NC, , No, , Yes, Array, No, , Yes, Array, 938.542, 64.8100000000001, No, No, No, TRUE, FALSE, Sinus Tachycardia, STEMI, Normal Sinus Rhythm, Right Arm - Left Arm Reversal, STEMI Anterior, Second Degree AV Block Type II (Mobitz II), STEMI (Inferior), STEMI (Septal), NSTEMI, Dextrocardia, STEMI (Lateral), 11, STEMI Anterior,, 983.61, 45.068, 292.071

6

FALSE

214, **60**, **8**, 1111, <30, male, Stage5MBBS, <10, 10s, Consent given, Chrome, Unknown OS Platform, 1, Regular, 140, Yes, No, 1036.581, 52.97, Yes, normal, 0.05, 0.5, No, 0.25, 1064.752, 28.171, 0, Yes, Array, No, , No, , Yes, Array, 1117.09, 52.338, 0.1, 0.33, 0.86, 0.36, No, , Yes, Array, No, , No, , 1202.373, 85.2830000000001, No, No, No, TRUE, FALSE, Sinus Tachycardia, STEMI, Normal Sinus Rhythm, Right Arm - Left Arm Reversal, STEMI Anterior, Second Degree AV Block Type II (Mobitz II), STEMI (Inferior), STEMI (Septal), NSTEMI, Dextrocardia, STEMI (Lateral), 11, STEMI,, 1304.193, 101.820, 320.583

NC

FALSE

216, **60**, **9**, 1111, <30, male, Stage5MBBS, <10, 10s, Consent given, Chrome, Unknown OS Platform, 985.694, Regular, 72, Yes, Yes, 1367.053, 62.86, Yes, normal, NC, 0.22, No, 0.2, 1411.205, 44.152, 0, No, , No, , No, , No, , 1430.263, 19.058, 0.1, NC, 1.05, 0.32, No, , No, , No, , No, , 1498.876, 68.6130000000001, No, No, No, FALSE, FALSE, Sinus Tachycardia, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), 3, Normal Sinus

Rhythm,, 1540.287, 41.411, 236.094

7

FALSE

218, **60**, **10**, 1111, <30, male, Stage5MBBS, <10, 10s, Consent given, Chrome, Unknown OS Platform, 1542.757, Regular, 57, Yes, Yes, 1590.737, 50.45, Yes, normal, 0.12, 0.12, No, 0.16, 1628.785, 38.048, 0, No, , No, , No, , Yes, Array, 1649.482, 20.6969999999999, 0.1, 0.35, 1, 0.34, No, , Yes, Array, No, , No, , 1703.905, 54.423, No, No, No, TRUE, FALSE, STEMI, Sinus Bradycardia, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), STEMI Anterior, STEMI (Lateral), STEMI (Inferior), STEMI (Septal), NSTEMI, 9, STEMI Anterior,, 1725.566, 21.661, 185.279

7

FALSE

204, **62**, **6**, ecg, <30, male, student, <10, 10s, Consent given, Chrome, Mac OS X, USER NOT FINISHED YET, Regular, 148, Yes, No, 88.462, 88.46, No, none, NC, NC, No, NC, 103.587, 15.125, 119, No, , No, , No, , No, , 150.724, 47.137, 0.15, NC, NC, , No, , No, , No, , No, , 189.86, 39.136, No, No, No, FALSE, FALSE, Sinus Tachycardia, Normal Sinus Rhythm, Junctional Rhythm, Second Degree AV Block Type II (Mobitz II), Atrial Flutter, 5, Normal Sinus Rhythm,, 233.875, 44.015, 233.875

NC

FALSE

205, **62**, **7**, ecg, <30, male, student, <10, 10s, Consent given, Chrome, Mac OS X, USER NOT FINISHED YET, Not regular, NC, No, No, 237.285, 3.41, No, none, NC, NC, No, NC, 238.16, 0.875, 0, No, , No, , No, , No, , 240.579, 2.41900000000001, NC, NC, NC, , No, , No, , No, , No, , 242.764, 2.185, No, No, No, FALSE, FALSE, , 1, Normal Sinus Rhythm,, 249.875, 7.111, 16.000

NC

FALSE

213, **67**, **6**, ECG , <30, female, F1, <10, 10s, Consent given, Handheld Browser, iPhone, USER NOT FINISHED YET, Not regular, 160, No, No, 88.086, 88.09, No, none, NC, NC, No, NC, 111.254, 23.168, 107, No, , No, , No, , No, , 203.932, 92.678, NC, NC, NC, , No, , No, , No, , No, , 215.696, 11.764, No, No, No, FALSE, FALSE, Sinus Tachycardia, Normal Sinus Rhythm, Junctional Rhythm, Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), Atrial Flutter, 6, Ventricular Tachycardia,, 295.749, 80.053, 295.749

0

FALSE

215, **67**, **7**, ECG , <30, female, F2, <10, 10s, Consent given, Handheld Browser, iPhone, USER NOT FINISHED YET, Regular, 71, Yes, Yes, 357.09, 61.34, Yes, normal, 0.04, 2.02, No, 0.1, 420.852, 63.762, -33, No, , No, , No, , No, , 453.39, 32.538, 0.06, 0.44, NC, Adjust the R-R interval, No, , No, , No, , No, , 508.007, 54.617, No, No, No, FALSE, FALSE, Sinus Tachycardia, Normal Sinus Rhythm, 2, Normal Sinus Rhythm,, 528.911, 20.904, 233.162

NC

FALSE

217, **67**, **8**, ECG , <30, female, F3, <10, 10s, Consent given, Handheld Browser, iPhone, 299.801, Regular, 85, Yes, Yes, 583.574, 54.66, Yes, normal, 0.04, 0.51, Yes, NC, 621.083, 37.509, 0, Yes, Array, No, , No, , No, , 650.461, 29.378, 0.04, 0.2, 0.8, 0.22, Yes, Array, No, , No, , No, , 705.668, 55.207, No, No, No, FALSE, FALSE, Second Degree AV Block Type I (Wenckebach / Mobitz I), Third Degree AV Block (complete heart block), Sinus Tachycardia, Normal Sinus Rhythm, 4, Normal Sinus Rhythm,, 754.736, 49.068, 225.825

0

FALSE

219, **67**, **9**, ECG , <30, female, F4, <10, 10s, Consent given, Handheld Browser, iPhone, 757.376, Regular, 67, Yes, Yes, 824.193, 69.46, Yes, normal, 0.1, 2, No, NC, 893.814, 69.621, 2, No, , No, , No, , No, , 905.19, 11.3760000000001, 0.08, NC, NC, , Yes, Array, No, , No, , No, , 961.205, 56.015, No, No, No, FALSE, FALSE, Sinus Tachycardia, Normal Sinus Rhythm, 2, Normal Sinus Rhythm,, 983.585, 22.380, 228.849

NC

FALSE

220, **67**, **10**, ECG , <30, female, F5, <10, 10s, Consent given, Handheld Browser, iPhone, 985.656, Regular, 66, Yes, Yes, 1049.478, 65.89, Yes, normal, 0.12, 2.5, No, 0.16, 1074.341, 24.863, 0, No, , No, , No, , No, , 1078.117, 3.77600000000007, 0.09, 0.4, 1, , No, , No, , No, , No, , 1082.625, 4.50800000000004, No, No, No, TRUE, FALSE, Sinus Tachycardia, Normal Sinus Rhythm, 2, Normal Sinus Rhythm,, 1094.881, 12.256, 111.296

0

TRUE

222, **79**, **6**, ECG, <30, female, Student, <10, 10s, Consent given, Chrome, Unknown OS Platform, USER NOT FINISHED YET, Not regular, 100, No, No, 60.654, 60.65, No, other, NC, NC, No, NC, 124.901, 64.247, 30, No, , Yes, Array, Yes, Array, Yes, Array, 244.884, 119.983, NC, NC, NC, , No, , No, , No, , No, , 257.733, 12.849, No, No, No, FALSE, FALSE, STEMI, STEMI (Lateral), NSTEMI, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), Atrial Flutter, STEMI Anterior, STEMI (Inferior), STEMI (Septal), 10, STEMI (Lateral),, 324.066, 66.333, 324.066

NC

FALSE

223, **84**, **6**, Ecg, <30, male, Fy2, <10, 10s, Consent given, Handheld Browser, iPhone, USER NOT FINISHED YET, Not regular, 151, No, No, 50.62, 50.62, No, none, NC, NC, No, NC, 72.645, 22.025, -17, No, , No, , No, , No, , 127.687, 55.042, NC, NC, NC, , No, , No, , No, , No, , 134.917, 7.23, No, No, No, FALSE, FALSE, Sinus Tachycardia, Normal Sinus Rhythm, Junctional Rhythm, Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), Atrial Flutter, 6, Atr, 173.748, 38.831, 173.748

7

TRUE

224, **84**, **7**, Ecg, <30, male, Fy3, <10, 10s, Consent given, Handheld Browser, iPhone, USER NOT FINISHED YET, Not regular, NC, No, No, 179.285, 5.54, No, none, NC, NC, No, NC, 183.695, 4.410, 0, No, , No, , No, , No, , 187.65, 3.95500000000001, NC, NC, NC, , No, , No, , No, , No, , 192.348, 4.69800000000001, No, No, No, FALSE, FALSE, , 1, First Degree AV Block,, 237.906, 45.558, 64.158

9

FALSE

225, **89**, **1**, ECG, <30, female, Junior Dr (FY1), <10, 100s, Consent given, Chrome, Windows 7, 1, Regular, 85, Yes, Yes, 39.385, 39.39, Yes, normal, NC, NC, No, NC, 161.933, 122.548, -17, No, , No, , No, , No, , 271.763, 109.83, 0.04, 0.25, 0.6, 0.32, No, , Yes, Array, No, , Yes, Array, 612.671, 340.908, No, No, No, TRUE, TRUE, STEMI, STEMI Anterior, Normal Sinus Rhythm, STEMI (Lateral), STEMI (Inferior), STEMI (Septal), NSTEMI, 7, Anterolateral STEMI in sinus rhythm., 845.582, 232.911, 845.582

6

TRUE

226, **89**, **2**, ECG, <30, female, Junior Dr (FY1), <10, 100s, Consent given, Chrome, Windows 8, 849.582, Regular, 75, Yes, Yes, 974.997, 129.42, Yes, normal, NC, 2.68, No, NC, 1023.007, 48.010, 30, No, , No, , No, , Yes, Array, 1065.511, 42.504, 0.04, 0.2, 1.2, 0.18, No, , No, , No, , Yes, Array, 1727.322, 661.811, No, No, Yes, FALSE, FALSE, Right Arm - Left Arm Reversal, Normal Sinus Rhythm, Benign Early Repolarisation (J-point elevation,high take-off), Atrial Fibrillation, NSTEMI, Ventricular Tachycardia, Hyperkalaemia, Right Atrial Enlargement (RAE), Dextrocardia, 10, Normal sinus rhythm ? right arm - left arm reversal, 1834.82, 107.498, 989.238

2

FALSE

227, **89**, **3**, ECG, <30, female, Junior Dr (FY1), <10, 100s, Consent given, Chrome, Windows 9, 1837.64, Regular, 150, No, No, 1863.619, 28.80, Yes, normal, 0.08, 1.47, No, NC, 1922.219, 58.600, 0, No, , No, , No, , No, , 1963.815, 41.596, NC, 0.2, 0.4, 0.32, No, , No, , No, , No, , 2710.583, 746.768, Yes, No, No, FALSE, FALSE, Poor R Wave Progression, Normal Sinus Rhythm, Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), Chest leads placement error (V1-V5 reversal), 5, Sinus rhythm. right bundle branch block, 2792.299, 81.716, 957.479

NC

FALSE

228, **89**, **4**, ECG, <30, female, Junior Dr (FY1), <10, 100s, Consent given, Chrome, Windows 10, 2794.284, Not regular, 153, Yes, No, 5495.023, 2702.72, Yes, normal, NC, NC, No, NC, 5511.768, 16.745, 27, Yes, Array, No, , No, , No, , 5528.369, 16.6009999999997, 0.18, 0.04, 0.2, 0.09, No, Array, No, , No, , No, , 5560.968, 32.5990000000002, No, No, No, FALSE, FALSE, Normal Sinus Rhythm, 1, Ventricular tachycardia, 5568.818, 7.850, 2776.519

8

TRUE

229, **89**, **5**, ECG, <30, female, Junior Dr (FY1), <10, 100s, Consent given, Chrome, Windows 11, 5571.449, Regular, NC, No, No, 5594.989, 26.17, No, fibrillation, NC, NC, No, NC, 5599.789, 4.800, 0, No, , No, , No, , No, , 5613.721, 13.9319999999998, 0.04, 0.6, 0.61, 0.77, No, , No, , No, , No, , 5670.55, 56.8290000000006, No, No, No, FALSE, FALSE, Normal Sinus Rhythm, Second Degree AV Block Type I (Wenckebach / Mobitz I), Second Degree AV Block Type II (Mobitz II), Third Degree AV Block (complete heart block), Atrial Flutter, 5, Atrial Fibrillation,, 5688.816, 18.266, 119.998

7

FALSE

230, **96**, **1**, ECG 2, <30, male, FY1, <10, 10s, Consent given, Handheld Browser, iPhone, USER NOT FINISHED YET, Regular, 90, Yes, Yes, 78.711, 78.71, Yes, normal, 0.08, 1.48, No, 0.12, 165.289, 86.578, 0, No, , No, , No, , No, , 220.006, 54.717, 0.08, 0.37, 0.68, 0.45, No, , No, , No, , No, , 317.138, 97.132, No, No, No, FALSE, FALSE, Normal Sinus Rhythm, 1, Normal Sinus Rhythm,, 357.506, 40.368, 357.506

10

FALSE

231, **97**, **6**, SA, <30, female, F1, <10, 10s, Consent given, Firefox, Unknown OS Platform, USER NOT FINISHED YET, Regular, 160, Yes, No, 105.266, 105.27, No, other, NC, NC, No, NC, 147.084, 41.818, 0, Yes, Array, No, , No, , No, , 283.902, 136.818, 0.06, 0.3, NC, Adjust the R-R interval, No, , No, , No, , Yes, Array, 442.339, 158.437, No, Yes, No, FALSE, FALSE, Sinus Tachycardia, Normal Sinus Rhythm, NSTEMI, Atrial Flutter, Chest leads placement error (V1-V5 reversal), Hyperkalaemia, 6, Sinus Tachycardia,, 686.733, 244.394, 686.733

8

FALSE

Appendix D: Data for the IPI+DDA system (Control group)

id, **user_id**, **trial_id**, **age - less than**, **gender**, **occupation**, **experience - less than**, **diagnosed ecgs - less than**, **consent**, **user_browser**, **user_os**, **time_start**, **S5_diagnosis**, **S5_time_end**, , **conf_level**, **category_id**, , **Correct / Incorrect**

76, **22**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 0, Normal Sinus Rhythm,First Degree AV Block,, 344.702, 344.7, 4, 1, , FALSE

66, **23**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 0, Right Bundle Branch Block (RBBB),, 256.106, 256.1, 2, 1, , FALSE

61, **24**, uuj, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 0, Right Bundle Branch Block (RBBB),, 265.664, 265.7, 2, 1, , FALSE

71, **28**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 0, Normal Sinus Rhythm,, 168.064, 168.1, 4, 1, , FALSE

81, **29**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 0, Normal Sinus Rhythm,, 323.036, 323.0, 6, 1, , FALSE

91, **30**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 0, Junctional Rhythm,Normal sinus rhythm heart rate 70bpm, 359.543, 359.5, 2, 1, , FALSE

96, **31**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 0, regular sinus rhythm, heart rate 71bpm, atrial fibilliation, inverted QRS complexs present, right bundle branch block, 494.158, 494.2, 3, 1, , FALSE

86, **32**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 0, Normal Sinus Rhythm,n, 24.652, 24.7, 3, 1, , FALSE

126, **34**, UUJ, <30, male, student, <10, 10s, Consent given, Chrome, Windows 7, 0, Normal Sinus Rhythm,Normal Sinus Rhythm,, 86.005, 86.0, NC, 1, , FALSE

161, **42**, WG, 30-40, male, Cardiology, <10, 1000s, Consent given, Firefox, Windows 7, 0, Normal Sinus Rhythm,Benign Early Repolarisation (J-point elevation,high take-off),, 124.189, 124.2, NC, 1, , FALSE

166, **45**, WG, 40-50, male, Biomed Eng, <10, 10s, Consent given, Chrome, Windows 7, 0, normal, 55.021, 55.0, 8, 1, , FALSE

181, **52**, NWG, 40-50, male, Consultant, 20-30, 1000s, Consent given, Chrome, Unknown OS Platform, 0, STEMI Anterior,, 9.177, 9.2, 7, 1, , TRUE

186, **53**, ecg1, 30-40, female, researcher, <10, 10s, Consent given, Firefox, Windows 8.1, 0, Normal Sinus Rhuthm, HR100,, 95.347, 95.3, NC, 1, , FALSE

191, **55**, DEL, 40-50, male, EP, 20-30, 1000s, Consent given, Unknown Browser, Windows 7, 0, acute ST elevation myocardial infarction anteroseptal, 131.671, 131.7, 8, 1, , TRUE

196, **56**, ECG, <30, female, FY1, <10, 10s, Consent given, Chrome, Mac OS X, 0, STEMI (Lateral),, 109.985, 110.0, 6, 1, , TRUE

236, **57**, Ecg , <30, male, Gpst2, <10, 10s, Consent given, Handheld Browser, iPhone, 0, Lateral st elevation or high take off depending on clinical situation no obvious reciprocal change, 194.381, 194.4, 9, 1, , TRUE

201, **59**, ecg1, <30, female, student, <10, 10s, Consent given, Safari, Mac OS X, 0, STEMI Anterior,, 29.634, 29.6, NC, 1, , TRUE

216, **60**, 1111, <30, male, Stage5MBBS, <10, 10s, Consent given, Chrome, Unknown OS Platform, 0, anterior STEMI, 48.495, 48.5, 10, 1, , TRUE

211, **61**, Jonny, <30, male, Fy1 doctor, <10, 100s, Consent given, Handheld Browser, iPhone, 0, Normal Sinus Rhythm,, 81.579, 81.6, 8, 1, , FALSE

206, **62**, ecg, <30, male, student, <10, 10s, Consent given, Chrome, Mac OS X, 0, STEMI Anterior,STEMI (Lateral),, 52.038, 52.0, NC, 1, , TRUE

221, **65**, Ecg, <30, female, Junior doc, <10, 10s, Consent given, Handheld Browser, iPhone, 0, Normal Sinus Rhythm,, 38.493, 38.5, 8, 1, , FALSE

226, **67**, ECG , <30, female, F1, <10, 10s, Consent given, Handheld Browser, iPhone, 0, STEMI (Lateral),, 82.953, 83.0, 9, 1, , TRUE

231, **70**, drt78, <30, male, zfghjk, <10, 10s, Consent given, Chrome, Mac OS X, 0, nsr, 16.304, 16.3, NC, 1, , FALSE

241, **73**, ECG, <30, male, F1, <10, 100s, Consent given, Handheld Browser, iPhone, 0, STEMI Anterior,, 70.261, 70.3, NC, 1, , TRUE

246, **74**, ECG, <30, female, Med Studen, <10, 10s, Consent given, Handheld Browser, iPhone, 0, STEMI (Lateral),, 73.809, 73.8, NC, 1, , TRUE

251, **79**, ECG, <30, female, Student, <10, 10s, Consent given, Chrome, Unknown OS Platform, 0, STEMI Anterior,, 64.873, 64.9, 8, 1, , TRUE

256, **80**, ECG, <30, female, Med studet, <10, 10s, Consent given, Chrome, Unknown OS Platform, 0, STEMI

Anterior,STEMI (Lateral),, 33.673, 33.7, 7, 1, , TRUE

261, **84**, Ecg, <30, male, Fy2, <10, 10s, Consent given, Handheld Browser, iPhone, 0, Normal Sinus Rhythm,, 29.282, 29.3, 9, 1, , FALSE

266, **97**, SA, <30, female, F1, <10, 10s, Consent given, Firefox, Unknown OS Platform, 0, STEMI,, 69.422, 69.4, 8, 1, , TRUE

271, **98**, ECG, <30, male, HO, <10, 100s, Consent given, Chrome, Mac OS X, 0, anterolateral STEMI, 9.567, 9.6, 8, 1, , TRUE

77, **22**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 354.921, Sinus Bradycardia,Left Ventricular Hypertrophy (LVH),, 708.134, 363.432, NC, 2, , TRUE

67, **23**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 275.269, Left Ventricular Hypertrophy (LVH),, 409.958, 153.852, 2, 2, , TRUE

62, **24**, uuj, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 279.866, Left Ventricular Hypertrophy (LVH),, 394.059, 128.395, 4, 2, , TRUE

72, **28**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 179.482, Left Ventricular Hypertrophy (LVH),, 356.634, 188.570, NC, 2, , TRUE

82, **29**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 343.067, Right Bundle Branch Block (RBBB),Sinus Bradycardia,, 549.257, 226.221, 3, 2, , FALSE

92, **30**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 365.861, Normal Sinus Rhythm,Left Bundle Branch Block (LBBB), , 792.669, 433.126, 3, 2, , FALSE

97, **31**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 505.151, Normal Sinus Rhythm,Left Bundle Branch Block (LBBB),Right Atrial Enlargement (RAE),, 854.938, 360.780, NC, 2, , FALSE

87, **32**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 26.585, Normal Sinus Rhythm,Left Bundle Branch Block (LBBB),Right Atrial Enlargement (RAE),, 46.495, 21.843, NC, 2, , FALSE

127, **34**, UUJ, <30, male, student, <10, 10s, Consent given, Chrome, Windows 7, 88.033, normal sinus rhythm with suggestion of left ventricular hypertrophy , 166.465, 80.460, NC, 2, , TRUE

162, **42**, WG, 30-40, male, Cardiology, <10, 1000s, Consent given, Firefox, Windows 7, 144.252, Normal Sinus Rhythm,Left Ventricular Hypertrophy (LVH),NSTEMI,Myocardial Ischaemia,, 247.033, 122.844, NC, 2, , TRUE

167, **45**, WG, 40-50, male, Biomed Eng, <10, 10s, Consent given, Chrome, Windows 7, 61.026, Right Bundle Branch Block (RBBB),, 244.038, 189.017, 6, 2, , FALSE

182, **52**, NWG, 40-50, male, Consultant, 20-30, 1000s, Consent given, Chrome, Unknown OS Platform, 14.668, Wellens Syndrome,Left Ventricular Hypertrophy (LVH),, 38.785, 29.608, 8, 2, , TRUE

187, **53**, ecg1, 30-40, female, researcher, <10, 10s, Consent given, Firefox, Windows 8.1, 100.218, Sinus rhythm, HR 68, LVH, 177.809, 82.462, NC, 2, , TRUE

192, **55**, DEL, 40-50, male, EP, 20-30, 1000s, Consent given, Unknown Browser, Windows 7, 147.086, old non-Q myocardial infarction anterolateral, 206.859, 75.188, 8, 2, , FALSE

197, **56**, ECG, <30, female, FY1, <10, 10s, Consent given, Chrome, Mac OS X, 114.063, Pacemaker, 210.667, 100.682, 8, 2, , FALSE

237, **57**, Ecg , <30, male, Gpst2, <10, 10s, Consent given, Handheld Browser, iPhone, 202.354, Deep t wave inversion laterally with st depression of about 1-2mm. High lateral and inferior (in some leads) t wave inversion also, 365.7, 171.319, 10, 2, , FALSE

202, **59**, ecg1, <30, female, student, <10, 10s, Consent given, Safari, Mac OS X, 32.459, Hyperkalaemia,, 142.605, 112.971, 1, 2, , FALSE

217, **60**, 1111, <30, male, Stage5MBBS, <10, 10s, Consent given, Chrome, Unknown OS Platform, 50.766, Hyperkalaemia,, 102.48, 53.985, NC, 2, , FALSE

212, **61**, Jonny, <30, male, Fy1 doctor, <10, 100s, Consent given, Handheld Browser, iPhone, 88.777, Left Ventricular Hypertrophy (LVH),, 157.737, 76.158, 7, 2, , TRUE

207, **62**, ecg, <30, male, student, <10, 10s, Consent given, Chrome, Mac OS X, 53.505, NSTEMI,, 75.841, 23.803, NC, 2, , FALSE

222, **65**, Ecg, <30, female, Junior doc, <10, 10s, Consent given, Handheld Browser, iPhone, 43.415, Hyperkalaemia,, 78.069, 39.576, 6, 2, , FALSE
227, **67**, ECG , <30, female, F1, <10, 10s, Consent given, Handheld Browser, iPhone, 87.487, Left Ventricular Hypertrophy (LVH),NSTEMI,, 150.953, 68.000, 8, 2, , TRUE
232, **70**, drt78, <30, male, zfghjk, <10, 10s, Consent given, Chrome, Mac OS X, 19.959, nstemi, 31.788, 15.484, NC, 2, , FALSE
242, **73**, ECG, <30, male, F1, <10, 100s, Consent given, Handheld Browser, iPhone, 77.586, T wave inversion. , 122.363, 52.102, NC, 2, , FALSE
247, **74**, ECG, <30, female, Med Studen, <10, 10s, Consent given, Handheld Browser, iPhone, 79.119, Left Ventricular Hypertrophy (LVH),, 119.22, 45.411, NC, 2, , TRUE
252, **79**, ECG, <30, female, Student, <10, 10s, Consent given, Chrome, Unknown OS Platform, 69.393, NSTEMI,, 106.949, 42.076, 0, 2, , FALSE
257, **80**, ECG, <30, female, Med studet, <10, 10s, Consent given, Chrome, Unknown OS Platform, 36.474, Myocardial Ischaemia,NSTEMI,, 80.514, 46.841, 3, 2, , FALSE
262, **84**, Ecg, <30, male, Fy2, <10, 10s, Consent given, Handheld Browser, iPhone, 32.304, St depression , 145.74, 116.458, NC, 2, , FALSE
267, **97**, SA, <30, female, F1, <10, 10s, Consent given, Firefox, Unknown OS Platform, 80.782, NSTEMI,, 140.803, 71.381, 4, 2, , FALSE
272, **98**, ECG, <30, male, HO, <10, 100s, Consent given, Chrome, Mac OS X, 12.702, anterolateral NSTEMI w old inferior infarct, 25.954, 16.387, 8, 2, , FALSE
78, **22**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 709.984, Right Atrial Enlargement (RAE),Sinus Tachycardia,, 879.681, 171.547, NC, 3, , TRUE
68, **23**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 413.707, Right Atrial Enlargement (RAE),, 585.944, 175.986, 3, 3, , TRUE
63, **24**, uuj, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 396.651, Right Atrial Enlargement (RAE),, 587.428, 193.369, 4, 3, , TRUE
73, **28**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 359.55, Left Bundle Branch Block (LBBB),, 563.072, 206.438, NC, 3, , FALSE
83, **29**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 554.125, Right Atrial Enlargement (RAE),, 974.314, 425.057, 2, 3, , TRUE
93, **30**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 795.67, Atrial Flutter,Right Atrial Enlargement (RAE),Poor R Wave Progression, , 990.293, 197.624, 2, 3, , TRUE
98, **31**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 857.412, Right Atrial Enlargement (RAE),Normal Sinus Rhythm,Atrial Flutter,, 1024.89, 169.952, 4, 3, , TRUE
88, **32**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 47.68, Right Atrial Enlargement (RAE),Atrial Flutter,Poor R Wave Progression,a, 208.367, 161.872, NC, 3, , TRUE
128, **34**, UUJ, <30, male, student, <10, 10s, Consent given, Chrome, Windows 7, 167.614, sinus tachycardia with suggestion of right atrial enlargement, 255.116, 88.651, NC, 3, , TRUE
163, **42**, WG, 30-40, male, Cardiology, <10, 1000s, Consent given, Firefox, Windows 7, 254.249, Sinus Tachycardia,Right Atrial Enlargement (RAE),, 327.167, 80.134, NC, 3, , TRUE
168, **45**, WG, 40-50, male, Biomed Eng, <10, 10s, Consent given, Chrome, Windows 7, 247.094, Myocardial Ischaemia,, 526.026, 281.988, NC, 3, , FALSE
183, **52**, NWG, 40-50, male, Consultant, 20-30, 1000s, Consent given, Chrome, Unknown OS Platform, 44.785, Sinus Tachycardia,Bi-atrial Enlargement,, 132.532, 93.747, 6, 3, , FALSE
188, **53**, ecg1, 30-40, female, researcher, <10, 10s, Consent given, Firefox, Windows 8.1, 179.041, Sinus tachycardia, hr 110, LAE, RAE,, 389.175, 211.366, NC, 3, , TRUE
193, **55**, DEL, 40-50, male, EP, 20-30, 1000s, Consent given, Unknown Browser, Windows 7, 210.883, P pulmonale, otherwise normal, 310.399, 103.540, 10, 3, , FALSE

198, **56**, ECG, <30, female, FY1, <10, 10s, Consent given, Chrome, Mac OS X, 213.972, Left Bundle Branch Block (LBBB),, 262.042, 51.375, 1, 3, , FALSE

238, **57**, Ecg , <30, male, Gpst2, <10, 10s, Consent given, Handheld Browser, iPhone, 367.23, ?, 2071.027, 1705.327, NC, 3, , FALSE

203, **59**, ecg1, <30, female, student, <10, 10s, Consent given, Safari, Mac OS X, 145.393, Left Bundle Branch Block (LBBB),, 182.338, 39.733, NC, 3, , FALSE

218, **60**, 1111, <30, male, Stage5MBBS, <10, 10s, Consent given, Chrome, Unknown OS Platform, 104.664, Wolff-Parkinson-White Syndrome (WPW),, 207.291, 104.811, 1, 3, , FALSE

213, **61**, Jonny, <30, male, Fy1 doctor, <10, 100s, Consent given, Handheld Browser, iPhone, 160.157, Left Atrial Enlargement (LAE),, 221.669, 63.932, NC, 3, , FALSE

208, **62**, ecg, <30, male, student, <10, 10s, Consent given, Chrome, Mac OS X, 76.834, d, 171.168, 95.327, NC, 3, , FALSE

223, **65**, Ecg, <30, female, Junior doc, <10, 10s, Consent given, Handheld Browser, iPhone, 82.581, Chest leads placement error (V1-V5 reversal),, 370.656, 292.587, 1, 3, , FALSE

228, **67**, ECG , <30, female, F1, <10, 10s, Consent given, Handheld Browser, iPhone, 153.68, Second Degree AV Block Type II (Mobitz II),, 204.91, 53.957, 6, 3, , FALSE

233, **70**, drt78, <30, male, zfghjk, <10, 10s, Consent given, Chrome, Mac OS X, 33.219, bifid p wave, 57.939, 26.151, NC, 3, , FALSE

243, **73**, ECG, <30, male, F1, <10, 100s, Consent given, Handheld Browser, iPhone, 126.465, Left Bundle Branch Block (LBBB),, 171.528, 49.165, 7, 3, , FALSE

248, **74**, ECG, <30, female, Med Studen, <10, 10s, Consent given, Handheld Browser, iPhone, 120.271, Left Bundle Branch Block (LBBB),, 172.356, 53.136, NC, 3, , FALSE

253, **79**, ECG, <30, female, Student, <10, 10s, Consent given, Chrome, Unknown OS Platform, 109.767, Right Bundle Branch Block (RBBB),, 164.156, 57.207, 7, 3, , FALSE

258, **80**, ECG, <30, female, Med studet, <10, 10s, Consent given, Chrome, Unknown OS Platform, 82.569, Normal Sinus Rhythm,, 139.778, 59.264, 1, 3, , FALSE

263, **84**, Ecg, <30, male, Fy2, <10, 10s, Consent given, Handheld Browser, iPhone, 150.865, Normal Sinus Rhythm,, 241.054, 95.314, NC, 3, , FALSE

268, **97**, SA, <30, female, F1, <10, 10s, Consent given, Firefox, Unknown OS Platform, 147.462, Right Bundle Branch Block (RBBB),, 212.672, 71.869, NC, 3, , FALSE

273, **98**, ECG, <30, male, HO, <10, 100s, Consent given, Chrome, Mac OS X, 28.098, incomplete LBBB, 304.443, 278.489, 1, 3, , FALSE

79, **22**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 881.062, Ventricular Tachycardia,, 911.522, 31.841, 6, 4, , TRUE

69, **23**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 589.805, Ventricular Tachycardia,, 627.76, 41.816, NC, 4, , TRUE

64, **24**, uuj, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 593.187, Ventricular Tachycardia,, 628.949, 41.521, NC, 4, , TRUE

74, **28**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 564.654, Ventricular Flutter, 662.672, 99.600, 7, 4, , FALSE

84, **29**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 981.229, Ventricular Tachycardia,, 1227.416, 253.102, 3, 4, , TRUE

94, **30**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 992.458, Atrial Flutter,Ventricular Tachycardia,Supraventricular Tachycardia,Atrial Fibrillation,, 1136.519, 146.226, 2, 4, , TRUE

99, **31**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 1028.74, Atrial Fibrillation,Supraventricular Tachycardia,Junctional Rhythm,, 1298.563, 273.673, 4, 4, , FALSE

89, **32**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 209.463, Atrial Flutter,Atrial Fibrillation,, 375.583, 167.216, NC, 4, , FALSE

129, **34**, UUJ, <30, male, student, <10, 10s, Consent given, Chrome, Windows 7, 256.133, Ventricular Tachycardia,, 387.719, 132.603, NC, 4, , TRUE

164, **42**, WG, 30-40, male, Cardiology, <10, 1000s, Consent given, Firefox, Windows 7, 328.208, Ventricular Tachycardia,, 346.229, 19.062, NC, 4, , TRUE

169, **45**, WG, 40-50, male, Biomed Eng, <10, 10s, Consent given, Chrome, Windows 7, 528.014, Ventricular Tachycardia,, 633.285, 107.259, 6, 4, , TRUE

184, **52**, NWG, 40-50, male, Consultant, 20-30, 1000s, Consent given, Chrome, Unknown OS Platform, 138.653, Ventricular Tachycardia,, 147.313, 14.781, 8, 4, , TRUE

189, **53**, ecg1, 30-40, female, researcher, <10, 10s, Consent given, Firefox, Windows 8.1, 390.575, VT,HR 180, 777.667, 388.492, NC, 4, , TRUE

194, **55**, DEL, 40-50, male, EP, 20-30, 1000s, Consent given, Unknown Browser, Windows 7, 313.215, wide complex tachycardia of RBBB pattern, 364.461, 54.062, 10, 4, , FALSE

199, **56**, ECG, <30, female, FY1, <10, 10s, Consent given, Chrome, Mac OS X, 264.06, Ventricular Tachycardia,, 277.364, 15.322, 10, 4, , TRUE

239, **57**, Ecg , <30, male, Gpst2, <10, 10s, Consent given, Handheld Browser, iPhone, 2073.145, Ventricular taychcardia , 2098.587, 27.560, 9, 4, , TRUE

204, **59**, ecg1, <30, female, student, <10, 10s, Consent given, Safari, Mac OS X, 183.545, Ventricular Tachycardia,, 274.15, 91.812, NC, 4, , TRUE

219, **60**, 1111, <30, male, Stage5MBBS, <10, 10s, Consent given, Chrome, Unknown OS Platform, 208.704, Ventricular Tachycardia,, 241.8, 34.509, 3, 4, , TRUE

214, **61**, Jonny, <30, male, Fy1 doctor, <10, 100s, Consent given, Handheld Browser, iPhone, 223.392, Ventricular Tachycardia,, 257.459, 35.790, 9, 4, , TRUE

209, **62**, ecg, <30, male, student, <10, 10s, Consent given, Chrome, Mac OS X, 172.187, Supraventricular Tachycardia,, 183.342, 12.174, NC, 4, , FALSE

224, **65**, Ecg, <30, female, Junior doc, <10, 10s, Consent given, Handheld Browser, iPhone, 373.85, Ventricular Tachycardia,, 427.099, 56.443, NC, 4, , TRUE

229, **67**, ECG , <30, female, F1, <10, 10s, Consent given, Handheld Browser, iPhone, 209.319, Ventricular Tachycardia,, 222.73, 17.820, 10, 4, , TRUE

234, **70**, drt78, <30, male, zfghjk, <10, 10s, Consent given, Chrome, Mac OS X, 59.115, Ventricular Tachycardia,, 75.022, 17.083, NC, 4, , TRUE

244, **73**, ECG, <30, male, F1, <10, 100s, Consent given, Handheld Browser, iPhone, 173.315, Ventri, 191.965, 20.437, NC, 4, , FALSE

249, **74**, ECG, <30, female, Med Studen, <10, 10s, Consent given, Handheld Browser, iPhone, 173.432, Ventricular Tachycardia,, 205.979, 33.623, NC, 4, , TRUE

254, **79**, ECG, <30, female, Student, <10, 10s, Consent given, Chrome, Unknown OS Platform, 167.423, Supraventricular Tachycardia,, 228.001, 63.845, NC, 4, , FALSE

259, **80**, ECG, <30, female, Med studet, <10, 10s, Consent given, Chrome, Unknown OS Platform, 141.73, Ventricular Tachycardia,, 156.69, 16.912, NC, 4, , TRUE

264, **84**, Ecg, <30, male, Fy2, <10, 10s, Consent given, Handheld Browser, iPhone, 245.027, Ventricular Tachycardia,, 285.544, 44.490, 8, 4, , TRUE

269, **97**, SA, <30, female, F1, <10, 10s, Consent given, Firefox, Unknown OS Platform, 214.925, Ventricular Tachycardia,, 262.105, 49.433, 10, 4, , TRUE

274, **98**, ECG, <30, male, HO, <10, 100s, Consent given, Chrome, Mac OS X, 309.759, svt with abberancy, 759.004, 454.561, 3, 4, , FALSE

80, **22**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 914.072, Sinus Tachycardia,Left Ventricular Hypertrophy (LVH),, 1231.389, 319.867, 5, 5, , FALSE

70, **23**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 628.883, accelerated junctional rhythm , 725.193, 97.433, 4, 5, , FALSE

65, **24**, uuj, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 629.859, Junctional Rhythm,(accelerated), 724.667, 95.718, 5, 5, , FALSE

75, **28**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 668.36, Junctional Tachycardia, 770.976, 108.304, 5, 5, , FALSE

85, **29**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 1228.966, Right Atrial Enlargement (RAE),Sinus Tachycardia,, 1270.816, 43.400, 3, 5, , FALSE

95, **30**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 1140.214, Ventricular Tachycardia,Left Ventricular Hypertrophy (LVH), pre-excitatory delta wave 220bpm, 1462.202, 325.683, 2, 5, , FALSE

100, **31**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 1302.557, Normal Sinus Rhythm,Atrial Fibrillation,Left Ventricular Hypertrophy (LVH),, 1513.609, 215.046, 5, 5, , FALSE

90, **32**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 376.55, Ventricular Tachycardia,Left Atrial Enlargement (LAE),Left Ventricular Hypertrophy (LVH),, 664.453, 288.870, 5, 5, , FALSE

130, **34**, UUJ, <30, male, student, <10, 10s, Consent given, Chrome, Windows 7, 389.061, accelerated junctional rhythm , 428.636, 40.917, 5, 5, , FALSE

165, **42**, WG, 30-40, male, Cardiology, <10, 1000s, Consent given, Firefox, Windows 7, 347.239, Supraventricular Tachycardia,, 379.803, 33.574, 5, 5, , TRUE

170, **45**, WG, 40-50, male, Biomed Eng, <10, 10s, Consent given, Chrome, Windows 7, 636.261, Sinus Tachycardia,, 956.26, 322.975, 7, 5, , FALSE

185, **52**, NWG, 40-50, male, Consultant, 20-30, 1000s, Consent given, Chrome, Unknown OS Platform, 151.402, Supraventricular Tachycardia,, 162.479, 15.166, 10, 5, , TRUE

190, **53**, ecg1, 30-40, female, researcher, <10, 10s, Consent given, Firefox, Windows 8.1, 778.786, NSVT, HR 180, 865.473, 87.806, 5, 5, , TRUE

195, **55**, DEL, 40-50, male, EP, 20-30, 1000s, Consent given, Unknown Browser, Windows 7, 367.476, narrow complex tachycardia - supraventricular tachycardia, 405.995, 41.534, 10, 5, , TRUE

200, **56**, ECG, <30, female, FY1, <10, 10s, Consent given, Chrome, Mac OS X, 279.383, Atrial Flutter,, 328.397, 51.033, 7, 5, , FALSE

240, **57**, Ecg , <30, male, Gpst2, <10, 10s, Consent given, Handheld Browser, iPhone, 2100.695, Flutter 2:1 block, 2132.652, 34.065, 9, 5, , FALSE

205, **59**, ecg1, <30, female, student, <10, 10s, Consent given, Safari, Mac OS X, 275.282, Atrial Fibrillation,, 309.416, 35.266, 5, 5, , FALSE

220, **60**, 1111, <30, male, Stage5MBBS, <10, 10s, Consent given, Chrome, Unknown OS Platform, 244.139, Left Ventricular Hypertrophy (LVH),, 419.136, 177.336, 0, 5, , FALSE

215, **61**, Jonny, <30, male, Fy1 doctor, <10, 100s, Consent given, Handheld Browser, iPhone, 262.472, Sinus Tachycardia,, 292.55, 35.091, 5, 5, , FALSE

210, **62**, ecg, <30, male, student, <10, 10s, Consent given, Chrome, Mac OS X, 184.178, Sinus Tachycardia,Left Ventricular Hypertrophy (LVH),, 214.255, 30.913, 5, 5, , FALSE

225, **65**, Ecg, <30, female, Junior doc, <10, 10s, Consent given, Handheld Browser, iPhone, 428.66, Supraventricular Tachycardia,, 462.777, 35.678, 5, 5, , TRUE

230, **67**, ECG , <30, female, F1, <10, 10s, Consent given, Handheld Browser, iPhone, 226.803, Sinus Tachycardia,, 248.172, 25.442, 8, 5, , FALSE

235, **70**, drt78, <30, male, zfghjk, <10, 10s, Consent given, Chrome, Mac OS X, 76.751, atrial flutte, 86.774, 11.752, 5, 5, , FALSE

245, **73**, ECG, <30, male, F1, <10, 100s, Consent given, Handheld Browser, iPhone, 198.934, Atrial Fibrillation,, 228.722, 36.757, 7, 5, , FALSE

250, **74**, ECG, <30, female, Med Studen, <10, 10s, Consent given, Handheld Browser, iPhone, 207.836, Supraventricular Tachycardia,, 242.301, 36.322, 5, 5, , TRUE

255, **79**, ECG, <30, female, Student, <10, 10s, Consent given, Chrome, Unknown OS Platform, 229.097, Sinus

Tachycardia,, 273.873, 45.872, 7, 5, , FALSE

260, **80**, ECG, <30, female, Med studet, <10, 10s, Consent given, Chrome, Unknown OS Platform, 157.89, Sinus Tachycardia,, 184.114, 27.424, 3, 5, , FALSE

265, **84**, Ecg, <30, male, Fy2, <10, 10s, Consent given, Handheld Browser, iPhone, 289.156, Supraventricular Tachycardia,, 319.527, 33.983, 8, 5, , TRUE

270, **97**, SA, <30, female, F1, <10, 10s, Consent given, Firefox, Unknown OS Platform, 267.263, Atrial Fibrillation,, 383.039, 120.934, 9, 5, , FALSE

275, **98**, ECG, <30, male, HO, <10, 100s, Consent given, Chrome, Mac OS X, 763.602, avnrt, 886.48, 127.476, 1, 5, , FALSE

136, **18**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, 0, Third Degree AV Block (complete heart block),, 60.3, 60.3, 1, 6, , FALSE

141, **19**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, 0, Ventricular Tachycardia,, 20.498, 20.5, NC, 6, , FALSE

116, **20**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, 0, Atrial Flutter,, 65.203, 65.2, 0, 6, , FALSE

101, **21**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 0, Supraventricular Tachycardia,, 80.122, 80.1, 0, 6, , FALSE

111, **25**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 0, Ventricular Tachycardia,, 46.958, 47.0, 0, 6, , FALSE

121, **26**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 0, Supraventricular Tachycardia,Wolff-Parkinson-White Syndrome (WPW),First Degree AV Block,, 45.683, 45.7, NC, 6, , FALSE

131, **27**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, 0, Ventricular Tachycardia,Right Bundle Branch Block (RBBB),Ventricular Tachycardia,Right Bundle Branch Block (RBBB),right axis deviation, junctional escape beat, 757.814, 757.8, 6, 6, , FALSE

106, **33**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 0, Ventricular Tachycardia,, 79.28, 79.3, NC, 6, , FALSE

146, **37**, NWG, 30-40, female, cardiology, 10-20, 1000s, Consent given, Chrome, Windows 7, 0, Ventricular Tachycardia,, 28.965, 29.0, 9, 6, , FALSE

151, **39**, NWG, 40-50, male, Clinical Electrophysiologist, 10-20, 100s, Consent given, Chrome, Windows 7, 0, Ventricular Tachycardia,, 73.515, 73.5, 9, 6, , FALSE

156, **40**, faelvenn, 30-40, male, Cardiology fellow, <10, 100s, Consent given, Chrome, Unknown OS Platform, 0, Atrial fibrillation with RBBB/LPH, 158.536, 158.5, 7, 6, , TRUE

171, **49**, 1, 30-40, male, Assistant Professor of Nursing, <10, 10s, Consent given, Chrome, Unknown OS Platform, 0, Atrial Fibrillation,Left Bundle Branch Block (LBBB),, 49.963, 50.0, 8, 6, , TRUE

176, **50**, DEL, 40-50, male, cardiologist, 20-30, 1000s, Consent given, Chrome, Windows 7, 0, Atrial Fibrillation,Wolff-Parkinson-White Syndrome (WPW),, 52.74, 52.7, 9, 6, , TRUE

137, **18**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 8, 62.658, Sinus Bradycardia,, 85.798, 25.498, 3, 7, , FALSE

142, **19**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, 21.691, Sinus Bradycardia,, 54.13, 33.632, NC, 7, , FALSE

117, **20**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, 76.018, Sinus Bradycardia,, 122.388, 57.185, 4, 7, , FALSE

102, **21**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 82.772, Normal Sinus Rhythm,, 147.205, 67.083, 3, 7, , FALSE

112, **25**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 48.384, Sinus Bradycardia,, 84.405, 37.447, 0, 7, , FALSE

122, **26**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 46.497, Junctional Rhythm,, 74.35, 28.667, NC, 7, , FALSE

132, **27**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, 759.467, Normal Sinus Rhythm,Normal Sinus Rhythm,left posterior fascicular block, 760.582, 2.768, 6, 7, , FALSE

107, **33**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 81.045, Sinus Bradycardia,, 136.92, 57.640, NC, 7, , FALSE

147, **37**, NWG, 30-40, female, cardiology, 10-20, 1000s, Consent given, Chrome, Windows 7, 34.413, First Degree AV Block,, 109.854, 80.889, 8, 7, , FALSE

152, **39**, NWG, 40-50, male, Clinical Electrophysiologist, 10-20, 100s, Consent given, Chrome, Windows 7, 77.413, Dextrocardia,, 174.838, 101.323, 9, 7, , FALSE

157, **40**, faelvenn, 30-40, male, Cardiology fellow, <10, 100s, Consent given, Chrome, Unknown OS Platform, 161.682, SR first degree AVB, 232.335, 73.799, 8, 7, , FALSE

172, **49**, 1, 30-40, male, Assistant Professor of Nursing, <10, 10s, Consent given, Chrome, Unknown OS Platform, 52.301, Normal Sinus Rhythm,First Degree AV Block,misplacement of limb leads, 161.432, 111.469, 7, 7, , TRUE

177, **50**, DEL, 40-50, male, cardiologist, 20-30, 1000s, Consent given, Chrome, Windows 7, 58.892, Right Arm - Left Arm Reversal,First Degree AV Block,Normal Sinus Rhythm,Left Atrial Enlargement (LAE),, 258.309, 205.569, 7, 7, , TRUE

138, **18**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 9, 89.081, Wolff-Parkinson-White Syndrome (WPW),, 119.332, 33.534, 3, 8, , FALSE

143, **19**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, 55.273, Third Degree AV Block (complete heart block),, 72.242, 18.112, NC, 8, , FALSE

118, **20**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, 125.504, Sinus Bradycardia,Atrial Flutter,Right Ventricular Hypertrophy (RVH),, 177.537, 55.149, 0, 8, , FALSE

103, **21**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 155.526, lpfb, 278.358, 131.153, 3, 8, , FALSE

113, **25**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 86.506, Left Bundle Branch Block (LBBB),, 151.685, 67.280, 0, 8, , FALSE

123, **26**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 75.485, Normal Sinus Rhythm,Left Atrial Enlargement (LAE),, 122.45, 48.100, NC, 8, , FALSE

133, **27**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, 761.684, Normal Sinus Rhythm,Right Ventricular Hypertrophy (RVH),Normal Sinus Rhythm,Right Ventricular Hypertrophy (RVH),, 950.251, 189.669, 6, 8, , FALSE

108, **33**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 138.693, Atrial Fibrillation,, 150.378, 13.458, NC, 8, , FALSE

148, **37**, NWG, 30-40, female, cardiology, 10-20, 1000s, Consent given, Chrome, Windows 7, 114.105, Chest leads placement error (V1-V5 reversal),, 162.001, 52.147, 9, 8, , FALSE

153, **39**, NWG, 40-50, male, Clinical Electrophysiologist, 10-20, 100s, Consent given, Chrome, Windows 7, 180.666, Poor R Wave Progression,Chest leads placement error (V1-V5 reversal),NSTEMI,, 404.513, 229.675, 7, 8, , FALSE

158, **40**, faelvenn, 30-40, male, Cardiology fellow, <10, 100s, Consent given, Chrome, Unknown OS Platform, 234.999, SR limb and chest lead misplacement, 270.183, 37.848, 6, 8, , FALSE

173, **49**, 1, 30-40, male, Assistant Professor of Nursing, <10, 10s, Consent given, Chrome, Unknown OS Platform, 164.148, misplacement of limb and chest leads, incomplete RBBB, 302.216, 140.784, NC, 8, , FALSE

178, **50**, DEL, 40-50, male, cardiologist, 20-30, 1000s, Consent given, Chrome, Windows 7, 261.573, Dextrocardia,, 410.996, 152.687, 8, 8, , TRUE

139, **18**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 10, 121.898, Right Bundle Branch Block (RBBB),, 153.613, 34.281, 3, 9, , FALSE

144, **19**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, 73.574, Right Bundle Branch Block (RBBB),, 86.58, 14.338, NC, 9, , FALSE

119, **20**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, 180.241, Left Ventricular Hypertrophy (LVH),, 248.139, 70.602, 3, 9, , FALSE

104, **21**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 280.29, normal sinus rhythm with first degree av block , 366.509, 88.151, 2, 9, , FALSE

114, **25**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 154.867, Sinus Bradycardia,Junctional Rhythm,, 195.935, 44.250, 1, 9, , FALSE

124, **26**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 123.752, Second Degree AV Block Type I (Wenckebach / Mobitz I),, 155.402, 32.952, NC, 9, , FALSE

134, **27**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, 951.335, Normal Sinus Rhythm,, 1077.868, 127.617, NC, 9, , FALSE

109, **33**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 155.731, Sinus Bradycardia,Junctional Rhythm,, 236.042, 85.664, 3, 9, , FALSE

149, **37**, NWG, 30-40, female, cardiology, 10-20, 1000s, Consent given, Chrome, Windows 7, 166.255, Chest leads placement error (V1-V5 reversal),, 210.451, 48.450, 7, 9, , TRUE

154, **39**, NWG, 40-50, male, Clinical Electrophysiologist, 10-20, 100s, Consent given, Chrome, Windows 7, 408.813, Normal Sinus Rhythm,posterior infarction, 574.827, 170.314, 6, 9, , FALSE

159, **40**, faelvenn, 30-40, male, Cardiology fellow, <10, 100s, Consent given, Chrome, Unknown OS Platform, 272.538, V1 - V5 lead misplacement, 487.419, 217.236, 7, 9, , TRUE

174, **49**, 1, 30-40, male, Assistant Professor of Nursing, <10, 10s, Consent given, Chrome, Unknown OS Platform, 303.32, Normal Sinus Rhythm,V1 and V5 misplaced, 368.351, 66.135, 7, 9, , TRUE

179, **50**, DEL, 40-50, male, cardiologist, 20-30, 1000s, Consent given, Chrome, Windows 7, 415.203, Chest leads placement error (V1-V5 reversal),Normal Sinus Rhythm,, 646.279, 235.283, 8, 9, , TRUE

140, **18**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 11, 156.365, Junctional Rhythm,, 166.709, 13.096, 2, 10, , FALSE

145, **19**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, 87.492, Normal Sinus Rhythm,, 100.573, 13.993, NC, 10, , TRUE

120, **20**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, 250.771, Sinus Bradycardia,, 294.156, 46.017, 0, 10, , FALSE

105, **21**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 368.741, Normal Sinus Rhythm,, 453.611, 87.102, NC, 10, , TRUE

115, **25**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 197.885, Normal Sinus Rhythm,, 238.959, 43.024, 0, 10, , TRUE

125, **26**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 156.386, Normal Sinus Rhythm,, 252.919, 97.517, NC, 10, , TRUE

135, **27**, UUJ, <30, male, Student, <10, 10s, Consent given, Chrome, Windows 7, 1079.372, Normal Sinus Rhythm,p mitrale, 1484.178, 406.310, NC, 10, , TRUE

110, **33**, UUJ, <30, female, student, <10, 10s, Consent given, Chrome, Windows 7, 237.844, Sinus Bradycardia,Junctional Rhythm,, 357.067, 121.025, NC, 10, , FALSE

150, **37**, NWG, 30-40, female, cardiology, 10-20, 1000s, Consent given, Chrome, Windows 7, 214.215, Benign Early Repolarisation (J-point elevation,high take-off),, 249.077, 38.626, 9, 10, , FALSE

155, **39**, NWG, 40-50, male, Clinical Electrophysiologist, 10-20, 100s, Consent given, Chrome, Windows 7, 579.417, Normal Sinus Rhythm,Left Atrial Enlargement (LAE),LAH, 683.835, 109.008, 7, 10, , TRUE

160, **40**, faelvenn, 30-40, male, Cardiology fellow, <10, 100s, Consent given, Chrome, Unknown OS Platform, 490.309, Q waves inferior leads, 613.746, 126.327, 7, 10, , FALSE

175, **49**, 1, 30-40, male, Assistant Professor of Nursing, <10, 10s, Consent given, Chrome, Unknown OS Platform, 372.883, Normal Sinus Rhythm,Pulmonary Embolism,, 420.272, 51.921, 8, 10, , TRUE

180, **50**, DEL, 40-50, male, cardiologist, 20-30, 1000s, Consent given, Chrome, Windows 7, 650.391, Normal Sinus Rhythm,, 747.063, 100.784, 7, 10, , TRUE